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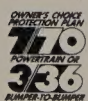
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NATURAL HISTORY

NOVEMBER 1991

COVER: By late autumn, a dark "eyebrow" is the last trace of this weasel's brown summer coat. Story on page 34. Photograph by Ted Levin.

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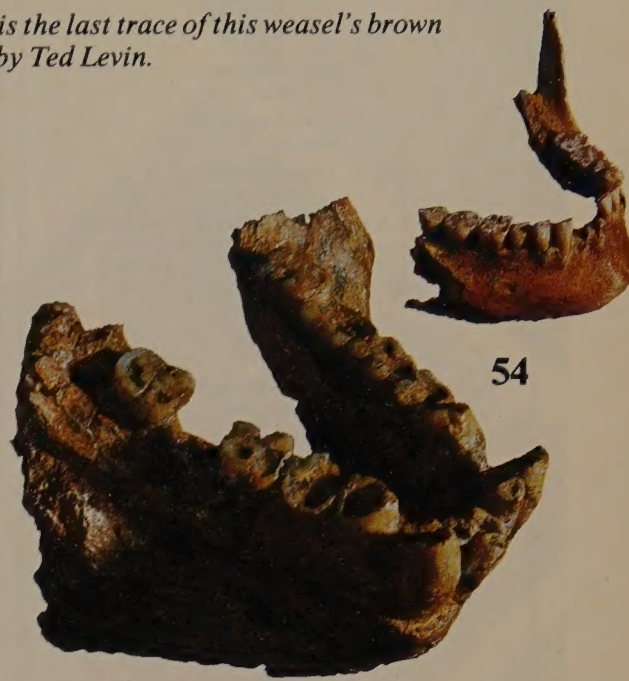
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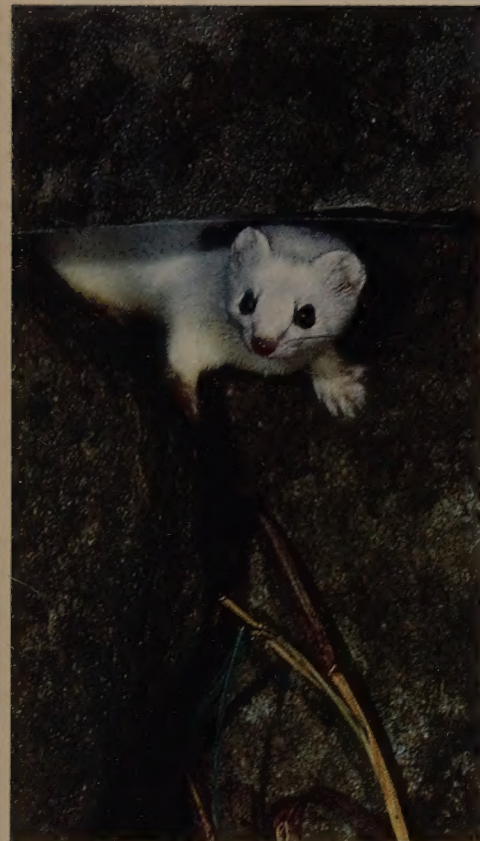
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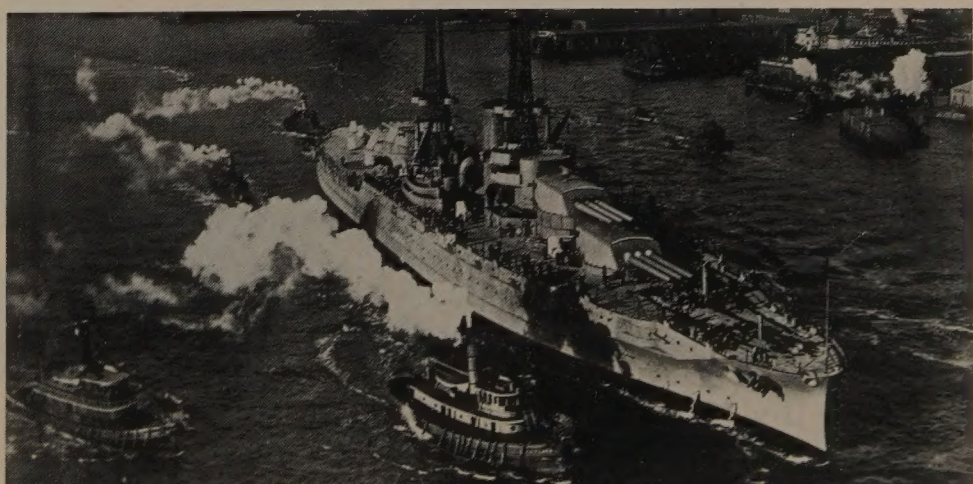
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*The USS Arizona in
New York Harbor, 1918*
National Park Service

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than anybody. Riding my bicycle home on a clear night, since we have dark skies here at the edge of the land, I often pause to scan the constellations. They are old friends. And I still like those star maps in *Natural History*, which look much the way they did sixty-five years ago. That's what your magazine (or its predecessor) did for me: it enriched my life immeasurably; and I still turn first to the "Celestial Events" column.

PAUL T. GILBERT
Santa Barbara, California

PRE-ALVAREZ IMPACT

In "Cretaceous Ground Zero," by Alan R. Hildebrand and William V. Boynton (June 1991), two important points went unmentioned. The first is that in 1978, two years before the K-T crater search was even initiated by the work of Alvarez et al., I identified the Yucatán feature as a probable impact at or near the K-T boundary in a report entitled "Preliminary Geophysical Interpretation Report—Progreso Area," written for Petróleos Mexicanos, the Mexican National Oil Company. In 1981, at the Society of Exploration Geophysicists Annual Meeting in Los Angeles, Antonio Camargo and I illustrated, located, and modeled the feature quite thoroughly in a series of slides accompanying our paper. We concluded our 1981 presentation with the words, "We would like to note the proximity of this feature in time to the hypothetical Cretaceous-Tertiary boundary event responsible for the emplacement of iridium-enriched clays on a global scale and invite investigation of this feature in the light of the meteorite impact-climatic alteration hypothesis for the late Cretaceous extinctions." While I am grateful that this further study has arisen, albeit a decade late, it is erroneous to imply, as the authors do, that this feature was "identified" in 1990 as a result of their impact wave studies. They state, "Although this crater lies on continental crust, we would never have found it without using impact wave deposits as our primary guide." This is misleading, since I had identified the feature more than ten years earlier on the basis of geophysical anomalies.

The second critical point glossed over is that the high-sensitivity aeromagnetic data obtained in 1978, not "decades earlier" as the article states, led to the identification of this feature. Only these data reveal the extraordinarily symmetrical structure that convinced me in 1978 that this was not a volcanic feature.

GLEN T. PENFIELD
*Carson Services, Inc.
Perkasie, Pennsylvania*

ALAN HILDEBRAND REPLIES:

Our work on the boundary deposits in Haiti and elsewhere, as described in "Cretaceous Ground Zero," led me to search in the Caribbean region for the impact crater. We are certainly not the first to suggest that the large crater lies buried on the Yucatán Peninsula; the early suggestions have an intriguing history.

Oil exploration in the 1950s by Petróleos Mexicanos in the area of the crater resulted in the discovery of the igneous rocks and the semicircular gravity anomaly. In 1968, exploration geophysicist Robert Baltosser reviewed the data and suggested that the unusual igneous rocks and gravity anomaly could represent a large, buried impact crater. He was unable to follow up on his verbal suggestion because of the proprietary nature of the data. In 1978, Glen Penfield was supervising an airborne magnetic survey in the area for Petróleos Mexicanos and wondered if the extraordinary circular magnetic field anomaly he saw might indicate a buried impact crater. He also found that the gravity anomaly coincided perfectly with the magnetic anomaly. In a confidential report to the oil company, Penfield independently suggested that the structure might be a crater with an age near the Cretaceous-Tertiary (K-T) boundary. Thus, both suggestions preceded the evidence published by the Alvarez group at Berkeley in 1980 linking the K-T mass extinction to a comet or an asteroid impact.

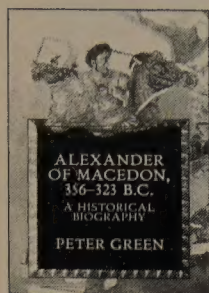
At the time of writing our article, I was unaware that Penfield had suggested in his 1981 presentation that the impact crater might be the K-T boundary crater (see *Sky and Telescope*, March 1982, pp. 249-50). Unfortunately, Penfield and Camargo never gained permission to publish any of the proprietary data and were unable to locate rock samples to search for definitive evidence of an impact. If either of these things had happened, the debate over the significance of the K-T boundary might not have lasted a decade.

After backtracking from the clues in the boundary layers and impact wave deposits, my colleagues at the University of Arizona and I became certain that the Caribbean region was the site of the impact, and we learned of the suggested Yucatán crater. Together with Penfield and Camargo, we were able to locate two sets of samples from both inside and outside the crater. Study of these confirmed its impact origin. Happily, other evidence keeps piling up that this is the K-T crater, but its precise age remains unknown, so that drilling will be needed to eliminate all uncertainty.

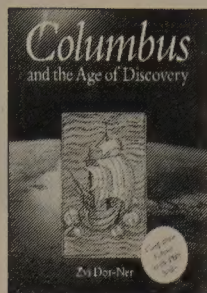
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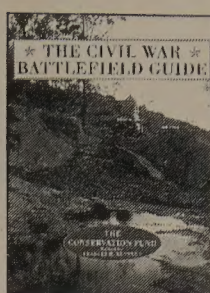
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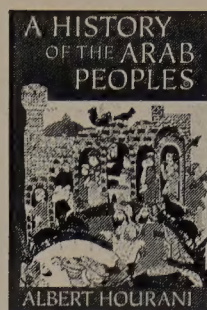
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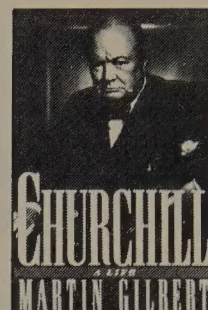
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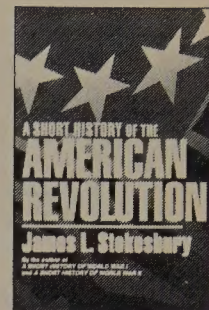
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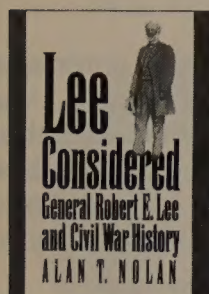
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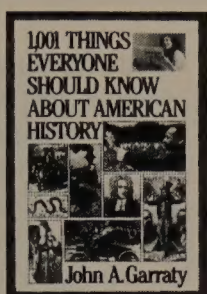
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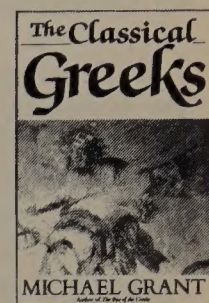
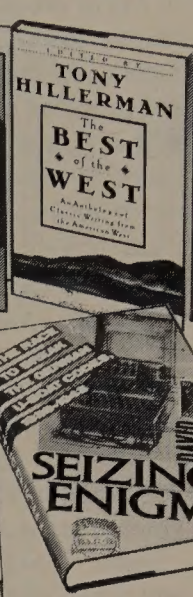
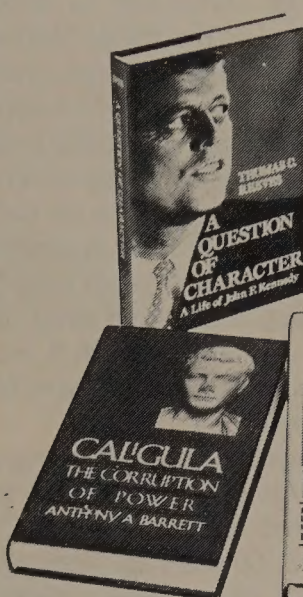


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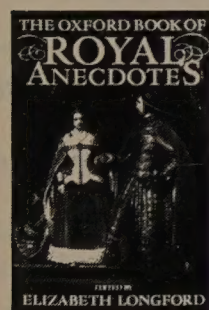
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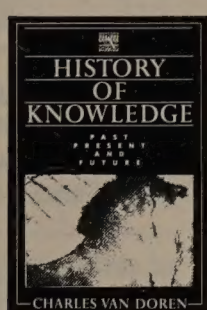
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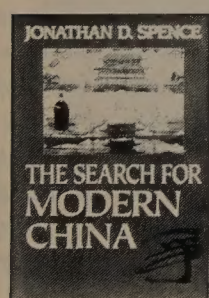
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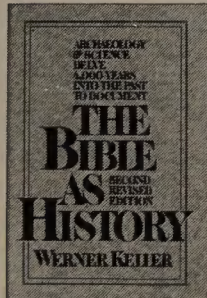
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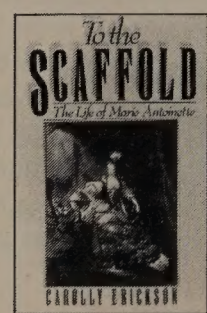
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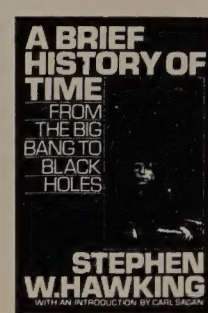
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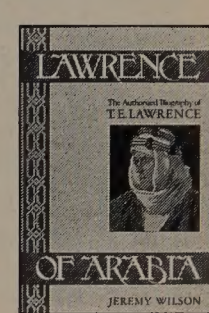
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The Owl, Shield, and Flint Blade

In A.D. 378, the Maya learned the art of conquest

by Linda Schele

War was already a part of Maya life at the beginning of their written history, some 2,000 years ago. Archeologists find the aftermath of war and captive taking in the dismembered or decapitated remains of sacrificial victims buried under floors of public buildings and in stone images and inscriptions that refer to such practices (when the names of the victims indicate their origin, they are invariably from rival settlements). We don't know if the early Maya went to war mainly to acquire territory, take booty, control conquered groups for labor, take captives for sacrifice in sanctification rituals, or a combination of these. But the first war of which there is a readable record—fought some 1,600 years ago between Tikal and Uaxactún, two kingdoms in the center of Petén, the northern region of Guatemala—laid a pattern for those that followed.

The seeds of this war were apparently sown centuries earlier, when the Maya in this lowland region first built pyramids and formal public buildings in their towns. As archeologist Richard Hansen has reported, large public architecture, com-

plete with the symbolism of political power, appeared at the site of Nakbe between 2,600 and 2,300 years ago (*Natural History*, May 1991). As it developed in the following two centuries, this symbolism came to include depictions of severed heads, apparently referring to the decapitation sacrifice that became so prominent in later Maya ritual. Images of kings have also been found from these early times, although by and large the rulers remain anonymous because so far we have found no readable texts.

El Mirador emerged as the largest of the cities in the region, while farther to the south, the towns of Uaxactún and Tikal, settled some 2,500 years ago, also grew in population and size, adding large public structures that displayed the same imagery of royal power. Depictions of early rulers of these two kingdoms show them standing with bound captives, indicating they were never peaceful neighbors. For reasons not yet understood, many of these cities failed during the second half of the first century A.D. El Mirador never came back, but the upheavals that created di-

saster for some kingdoms provided opportunities for others. Tikal and Uaxactún came through this period unscathed. Being less than twelve miles apart, however, they did not have the buffer of a no man's land between them and could not coexist as equals for long.

Peter Mathews, of the University of Calgary, was the first scholar to detect evidence of their great conflict. In a study

This is the eighth in a series of articles that explore recent findings and interpretations concerning the rise and fall of ancient Maya civilization.

of early inscriptions, he noticed that both Stela 5 at Uaxactún and Stela 31 at Tikal recorded the same date and action by a Tikal *ahaw*, or "holy lord." Mathews deduced that these texts recorded an important interaction between the two towns, that Tikal was the dominant partner, and that one of two political events was most likely involved—an alliance by marriage or a conquest. Based on the image included on Uaxactún Stela 5, my colleague David Freidel and I narrowed it down to the second alternative.

The stela is a stone monument erected at the base of a stairway of a remodeled temple. The text on the back of the stela records the date of the commemorated event, 8.17.1.4.12 11 Eb 15 Mac, or January 16, A.D. 378, and names Smoking-Frog, a lord of Tikal, as the protagonist. The front of the stela shows Smoking-Frog holding an obsidian-edged club and a spear-thrower (or throwing stick, used to launch spears or darts with great impetus) and wearing a uniform that in later monuments epitomizes a war of conquest. Only in defeat could Uaxactún have accorded a lord of a rival city such recognition.

Stela 31 at Tikal, erected fifty years later, provides no pictorial representation of the conquest, but the inscription repeats



Warriors on a Maya vase: the man at right wields a javelin and a spear-thrower.

Justin Kerr



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the same date, actor, and event. It also registers that the reigning king of Tikal at the time was Great-Jaguar-Paw, and that he celebrated the victory by an act of bloodletting from his genitals. From other inscriptions, we now know that Great-Jaguar-Paw was one of the most celebrated of Tikal's early rulers and that Smoking-Frog was his brother and, very probably, his war chief.

Later events confirm this was a war of conquest. A year after his victory, Smoking-Frog succeeded his brother, but he ruled not from Tikal but from Uaxactún. His empire now included both cities, and it was under his authority that his nephew, the son of Great-Jaguar-Paw, was installed as the new lord of Tikal. The absorption of Uaxactún into the hegemony of Tikal is reflected in various inscriptions at both sites and in the archeological record. Archeologist Juan Pedro Laporte, for example, points out that the architectural style of the conquered city began emulating Tikal soon after the victory.

The temple behind Stela 5 was remodeled as a victory monument, a constant reminder in Uaxactún of the new order. A grisly one, too. Archeologist Ledyard A. Smith reported finding five skeletons entombed within: an adult female with an unborn fetus, a second adult female, a child, and an infant. These were probably the wives and children of the defeated king, killed to end forever the royal line at Uaxactún. The defeated king himself had probably been stripped of his finery, bound, and carried back to Tikal to be tortured and sacrificed in public rituals. A recent study by Laporte concludes that the burial chamber was dug into the existing temple at Uaxactún, with the affected floor and step repaired after the bodies were entombed. Afterward the whole temple was encapsulated by new construction, and the victory stela was erected at the base of the stairway.

The war apparently took place at a time when the Maya of central Petén were intensifying their contacts with the huge city of Teotihuacán, in the central valley of Mexico far to the west. The nature of



Bearing his club and spear-thrower, the victorious Smoking-Frog dominates Stela 5 in the defeated city of Uaxactún.

Linda Schele

the interactions between these two cultural areas is still a matter of debate, but the archeological record shows that the highland people of Teotihuacán used lowland products, such as cotton, tropical bird feathers, and shell, while the Maya used highland products, such as obsidian, jade, and other minerals. Many of these exotic products were considered essential to the rituals that controlled the supernatural world, and access to them determined who could conduct public rites to demonstrate such control, as well as who could claim and exercise elite status. The

trade network that moved these and similar exotic commodities was intensifying at just the time of this war, so the conflict was as likely to have been over the wealth this trade promised as it was over the control of territory.

Contact with Teotihuacán may have contributed not only to the motive for this war but also to the means by which it was fought. I and others now believe that in this war, the spear-thrower, used in warfare by the Teotihuacanos, was adopted for the first time as a weapon in the Maya lowlands. Formerly, Maya kings and nobles used short-shafted spears that forced them into close-range combat, where the taking of captives was more important than killing foes. The javelins propelled by spear-throwers, instead, are long-distance weapons that can be thrown by masses of warriors, causing greater casualties. Although probably used for hunting, spear-throwers apparently did not figure in Maya politics until Smoking-Frog led Tikal's forces against Uaxactún.

This conclusion is supported in broad outline by the weapons that turn up at Maya sites. Before this time, they consist mainly of large, laurel-leaf-shaped points, suitable for thrusting spears, and tanged "daggers." The smaller points appropriate for projectile weapons—such as javelins flung with spear-throwers—become widespread later. But the main evidence for the change is the prominence of new images in subsequent depictions of conquest.

Victors are portrayed using a complex of symbols that seem to have been borrowed from Teotihuacán. These include the goggle-eyed war deity called Tlaloc by the later Aztecs, a trapeze-and-bar sign (the Mexican "year" sign), a full-bodied jaguar suit, a spherical (balloonlike) head-dress, a war serpent made in a mosaic pattern, owls of omen, spear-throwers and javelins, and square, flexible shields. Following the Tikal-Uaxactún war, the Maya everywhere adopted this symbolism and the ritual complex that went with it to represent conquest warfare for the rest of their history.

Most visibly, the Maya adopted the Te-



The flint-shield emblem that symbolizes war (bottom center) appears amid warriors decorating a Maya vase.

Justin Kerr

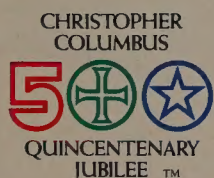
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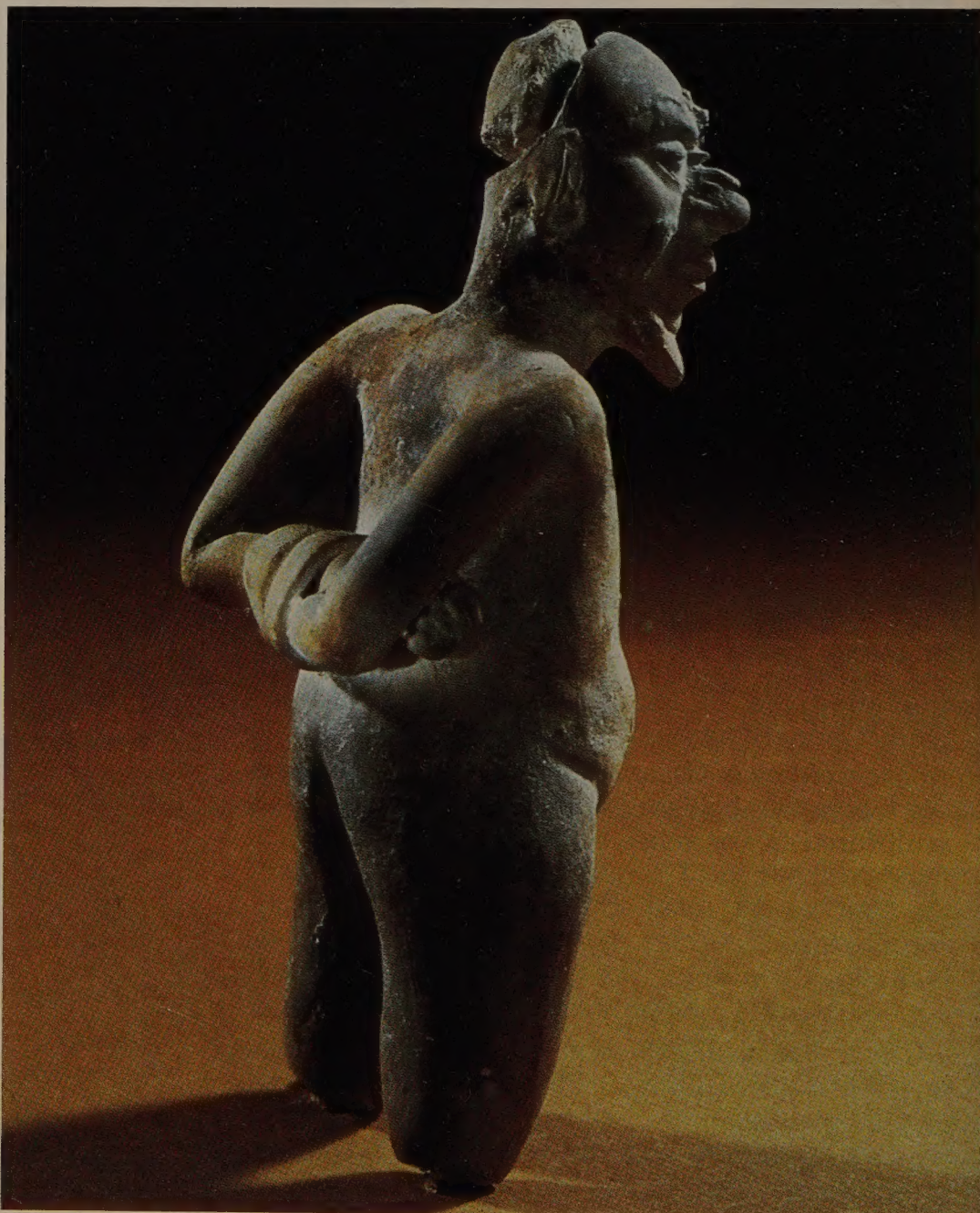
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otihuacán symbol for war—a round shield combined with crossed javelins and a rampant owl (a creature associated with prophecy and fortunetelling). To reflect their weaponry of choice, the Maya quickly modified this emblem to a flint blade, owl, and shield. This emblem embodied their word for war, *tok'-pakal*, "flint-shield" (the later Aztecs called war arrow-shield). The flint-shield was carried into battle in the form of a great banner to bring the power of the Other World into combat. For the Maya, war was a sacred activity fought with the power of the supernatural as well as the strength of the human arm. The alliance with the Other World enabled warriors to conquer not only their enemy's living royal clan but also their apotheosized ancestors.

The ancient Maya, as did their descendants in their battles against the invading Spaniards, went to war transformed into their *nahwals*, spiritual companions who were believed to share human souls. Warrior costumes evoked many different su-

pernatural animals and creatures, such as a jaguar, a bird, or a skeletal god of death. But the most important deity the Maya warriors invoked in warfare was Venus. Within thirty years of the Tikal-Uaxactún war, they began timing their battles to coincide with important stations of Venus (its maximum elongations, when it appears farthest from the sun, and certain of its risings, especially its first appearance as the evening star), and by the apparent standstills, or stationary points, of Jupiter and Saturn in their orbits, especially during periods of double or triple conjunctions, when the two planets crossed each other's positions two or three times within a matter of months. Maya writing employed a "star-shell" verb for these wars; I call them "star wars."

So important was the victory over Uaxactún that it became the most celebrated event of the early history of Tikal and the focus of memorials and political strategies for centuries to follow. Stormy-Sky, Great-Jaguar-Paw's grandson, who



A bound captive awaits his fate.

Justin Kerr; Art Museum, Princeton University

returned the seat of the kingship of the enlarged empire to Tikal, celebrated the victory as the pivotal event of his ancestral history. He commemorated the war in writing and images, for the first time explicitly joining the Tlaloc war symbolism with the critical positions of Venus in its cycle and with a long triple conjunction of Jupiter and Saturn. Stormy-Sky was the ruler responsible for erecting Stela 31 at Tikal and is depicted on it.

Conquest warfare, especially battles that resulted in territorial dominance and booty taking, were represented by this Tlaloc-Venus symbolic complex for the rest of Maya history. Tikal itself fell to this kind of attack in the sixth century when Caracol, a kingdom to the southeast, turned the tables and defeated the kingdom that first waged this kind of warfare. Later on, a distant descendant of Great-Jaguar-Paw (known to scholars as Ruler A) revived Tikal from its defeat and took an enemy king captive. The sacrifice of the defeated king took place on the thirteenth-katun (260th year) anniversary of the ritual in which Stormy-Sky had celebrated Tikal's victory over Uaxactún.

The prominence of battle and sacrifice in the public history commissioned by the Maya nobility suggest that much of it was highly ritualized—timed by astronomical events, fought between noble or high-ranked warriors who spent their lives training and practicing the craft, and designed to secure sacrificial victims for the great pageants that punctuated Maya life. But war was also fought to establish political and economic control over rivals, to garner the wealth of booty, and to control labor both by moving the losers and attracting surplus population from the no man's land between kingdoms (such immigration may have been crucial to retaining political clout, since research by anthropologist Rebecca Storey suggests that the death rate in all these cities exceeded their birthrate).

The consequences of losing these kinds of wars could be long-term and substantial, and the danger of attack apparently led to the formation of large coalitions of kingdoms. Such alliances fought each other throughout the sixth, seventh, and eighth centuries. One such coalition, composed of Caracol, Site Q (an unidentified site, possibly Calakmul), and Dos Pilas, attacked and defeated Tikal at least twice more after the first Caracol victory. These alliances were reinforced by judicious marriages, so that many of the great ruling families, such as those of Caracol and Site Q, became interrelated. These formal and informal alliances were not permanent or secure, however, for former ene-

mies became allies and former allies changed sides and attacked each other.

Each kingdom's prosperity depended on the formation and maintenance of alliances among its own lineages and with those of allied kingdoms. As populations grew during the late Classic period and kingdoms expanded into the no man's land between them, wars were sometimes fought within kingdoms against petty nobles trying to break away from the larger kingdoms.

Toward the end of the Classic period, in the eighth and ninth centuries, warfare may have become so chronic and disruptive that the social networks and agricultural systems that had given the Maya of

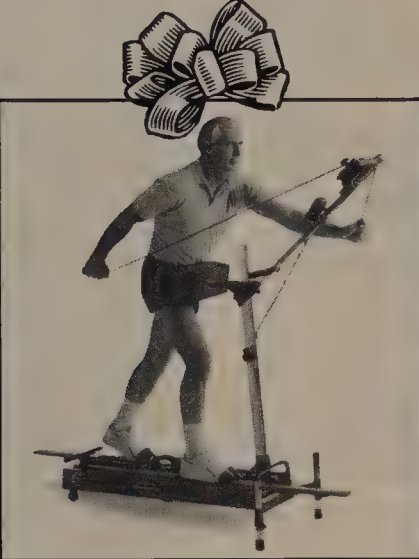
the southern lowlands civilized life in the first place could not survive intact. But the collapse of the cities in that region did not end the importance of the Tlaloc-Venus war complex. The so-called Toltecs of Chichén Itzá are Maya warriors dressed in the uniform of this same war complex.

In this phase of Maya history, centered in the northern lowlands, the flint-shield emblem was transformed once again to resemble more closely its original Teotihuacán form. The flint-shield of the Classic period became a round sun disk, with an ancestral warrior armed with spear-thrower and javelins emerging from an otherworldly portal to join his descendants in their fight to create an empire. □

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Fall in the House of Ussher

How foolish was the archbishop's precise date for creation?

by Stephen Jay Gould

I am uncomfortable enough in a standard four-in-hand tie; pity the poor seventeenth-century businessmen and divines, so often depicted in their constraining neck ruffs. The formidable gentleman in the accompanying engraving commands the Latin title *Jacobus Usserius, Archiepiscopus Armachanus, Totius Hiberniae Primas*, or James Ussher, Archbishop of Armagh, and Primate of All Ireland. He is known to us today almost entirely in ridicule—as the man who fixed the time of creation at 4004 B.C., and even had the audacity to name the date and hour: October 23 at midday.

Let me begin with a personal gloss on the caption to this engraving, for my misreading embodies, in microcosm, the entire theme of this essay. I confess that I have always been greatly amused by the term *primate*, used in its ecclesiastical sense as “an archbishop . . . holding the first place among the bishops of a province.” My merriment must be shared by all zoologists, for primates, to us, are monkeys and apes—members of the order Primates. Thus, when I see a man described as a “primate,” I can’t help thinking of a big gorilla. (Humans, of course, are also members of the order Primates, but zoologists, in using the term, almost always refer to nearly 200 other species of the group—that is, to lemurs, monkeys, and apes.)

But this amusement is silly, parochial, and misguided. The term comes from the Latin *primas*, meaning “chief” or “first.” In the mideighteenth century, Linnaeus introduced the word to zoology as a designation for the “highest” order of mammals—the group including humans. But the ecclesiastical usage has an equally obvious claim to proper etymology and



James Ussher, Primate of All Ireland

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substantial precedence in usage (the *Oxford English Dictionary* traces this meaning to 1205). Thus, we zoologists are the usurpers, not the guardians of a standard. (I wonder if preachers laugh when they see the term in a zoological book and think of a baboon running about in a neck ruff.) In any case, the archbishop of Armagh is titular head, hence primate, of the Anglo-Irish church, just as the archbishop of Canterbury is primate of all England.

This little tale mimics the forthcoming essay in miniature for two reasons:

1. I shall be defending Ussher's chronology as an honorable effort for its time and arguing that our usual ridicule only records a lamentable small-mindedness

based on mistaken use of present criteria to judge a distant and different past—just as our current amusement in picturing a primate of the church as a garbed ape inverts the history of usage, for the zoological definition is derivative, and the ecclesiastical primary.

2. The mental picture of a prelate as a garbed ape reinforces the worst parochialism that scientists often invoke in interpreting their history—the notion that progress in knowledge arises from victory in battle between science and religion, with religion defined as unthinking allegiance to dogma and obedience to authority, and science as objective searching for truth.

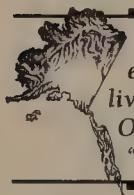
James Ussher (1581–1656) lived through the most turbulent of English centuries. He was born in the midst of Elizabeth's reign and died under Cromwell (who gave him a state funeral in Westminster Abbey, despite Ussher's royalist sentiments and his previous support for the executed Charles I). As a precocious scholar with a special aptitude for languages, Ussher entered Trinity College, Dublin, at its founding in 1594, when he was only thirteen years old. He was ordained a priest in 1601 and became a professor at Trinity (1607) and then vice chancellor on two occasions in 1614 and 1617. With his appointment as Archbishop of Armagh in 1625, he became head (or primate) of the Anglo-Irish church—a tough row to hoe in this preeminently Catholic land ("Romish" or "papist" as Ussher always said in the standard deprecations of his day). Ussher was vehement and unrelenting in his verbal assaults on Roman Catholicism (he wasn't too keen on Jews and other "infidels" either, but the issue rarely came up). His 1626 "Judgement of the Arch-Bishops and Bishops of Ireland" begins, for example:

The religion of the papists is superstitious and idolatrous; their faith and doctrine erroneous and heretical; their church . . . apostatical; to give them therefore a toleration, or to consent that they may freely exercise their religion . . . is a grievous sin.

One may cringe at the words (and no one can take Ussher as a model of toleration), but he was, in fact, regarded as a force for moderation and compromise at a time of fierce invective (read Milton's anti-Catholic pamphlets sometime if you want to get a feel for the rhetoric of those troubled years). Despite his opinions, Ussher continued to espouse debate, discussion, and negotiation. He preached to Catholics and delighted in meeting their champions in formal disputations. His own words were harsh, but he believed in triumph by force of argument, not by banishment, fines, imprisonment, and executions. In fact, even the hagiographical biographies, written soon after Ussher's death, criticize him for lack of enthusiasm in the daily politics of ecclesiastical affairs and for general unwillingness to carry out policies of intolerance. He was a scholar by temperament and, at best, a desultory administrator. He was in England at the outbreak of the civil war in 1642 and never returned again to Ireland. He spent most of his last decade engaged in study and publication—including, in 1650, the source of his current infamy: *Annales veteris testamenti, a prima mundi origine deducti*, "Annals of the Old Testament,

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Ussher became the symbol of ancient and benighted authoritarianism for a reason quite beyond his own intention. Starting about fifty years after his death, most editions of the "authorized," or King James, translation of the Bible began to carry his chronology in the thin column of annotations and cross-references usually placed between the two columns of text on each page. (The Gideon Society persisted in placing this edition in nearly every hotel room in America until about fifteen years ago; they now use a more modern translation and have omitted the column of annotations, including the chronology.) There, emblazoned on the first page of Genesis, stands the telltale date: 4004 B.C. Ussher's chronology therefore acquired an almost canonical status in English Bibles—hence his current infamy as a symbol of fundamentalism.

To this day, one can scarcely find a textbook in introductory geology that does not take a swipe at Ussher's date as the opening comment in an obligatory page or two on older concepts of the earth's age (before radioactive dating allowed us to get it right). Other worthies are praised for good tries in a scientific spirit (even if their

ages are way off), but Ussher is excoriated for biblical idolatry and just plain foolishness. How could anyone look at a hill, a lake, or a rock pile and not know that the earth must be ancient?

One text discusses Ussher under the heading "Rule of Authority" and later proposals under "Advent of the Scientific Method." We learn—although the statement is absolute nonsense—that Ussher's "date of 4004 B.C. came to be venerated as much as the sacred text itself." Another text places Ussher under "Early Speculation" and later writers under "Scientific Approach." These authors tell us that Ussher's date of 4004 B.C. "thus was incorporated into the dogma of the Christian Church" (an odd comment, given the tradition of Catholics, and of many Protestants as well, for allegorical interpretation of the "days" of Genesis). They continue: "For more than a century thereafter it was considered heretical to assume more than 6,000 years for the formation of the earth."

Even the verbs used to describe Ussher's efforts reek with disdain. In one text, Ussher "pronounced" his date; in a second, he "decreed" it; in a third, he "announced with great certainty that . . . the world had been created in the year 4004

B.C. on the 26th of October at nine o'clock in the morning!" (Ussher actually said October 23 at noon—but I found three texts with the same error of October 26 at nine, so they must be copying from each other.) This third text then continues: "Ussher's judgment of the age of the earth was gospel for fully 200 years."

Many statements drip with satire. Yet another textbook—and this makes six, so I am not merely taking potshots at rare silliness—regards Ussher's work as a direct "reaction against the scientific explorations of the Renaissance." We then hear about "the pronouncement by Archbishop Ussher of Ireland in 1664 that the Earth was created at 9:00 A.M., October 26, 4004 B.C. (presumably Greenwich mean time!)" Well, Ussher was then eight years dead, and his date for the earth's origin is again misreported. (I'll pass on the feeble joke about Greenwich time, except to say that Ussher used the Julian calendar and that such issues hardly arose in an age before rapid travel made the times of different places a matter of importance.)

Needless to say, in combating the illiberality of this textbook tradition, I will not defend the substance of Ussher's conclusion—for one claim of the standard cri-

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tique is undeniably justified: a 6,000-year-old earth did make a scientific geology impossible because any attempt to cram the empirical record of miles of strata and life's elaborate fossil history into such a moment requires a belief in miracles as causal agents.

Fair enough, but what sense can be made of blaming one age for impeding a much later system that worked by entirely different principles? To accuse Ussher of delaying the establishment of an empirical geology is much like blaming dinosaurs for holding back the later success of mammals. The proper criterion must be worthiness by honorable standards of one's own time. By this correct judgment, Ussher wins our respect just as dinosaurs now seem admirable and interesting in their own right (and not as imperfect harbingers of superior mammals in the inexorable progress of life). Models of inevitable progress, whether for the panorama of life or the history of ideas, are the enemy of sympathetic understanding, for they excoriate the past merely for being old (and therefore both primitive and benighted).

Of course Ussher could hardly have been more wrong about 4004 B.C., but his work was both honorable and interesting—therefore instructive for us today—for at least four reasons.

1. The excoriating textbook tradition depicts Ussher as a single misguided dose of darkness and dogma thrown into an otherwise more enlightened pot of knowledge—as if he alone, representing the church in an explicit rearguard action against science and scholarship, raised this issue to recapture lost ground. No idea about the state of chronological thinking in the seventeenth century could be more false.

Ussher represented the best of scholarship in his time. He was part of a substantial research tradition, a large community of intellectuals working toward a common goal under an accepted methodology—Ussher's shared "house" if you will pardon my irresistible title pun. Today we rightly reject a cardinal premise of that methodology—belief in biblical inerrancy—and we recognize that this false assumption allowed such a great error in estimating the age of the earth. But what intellectual phenomenon can be older, or more oft repeated, than the story of a large research program that impaled itself upon a false central assumption accepted by all practitioners? Do we regard all people who worked within such traditions as dishonorable fools? What of the scientists who assumed that continents were stable, that the hereditary material was protein,

or that all other galaxies lay within the Milky Way? These false and abandoned efforts were pursued with passion by brilliant and honorable scientists. How many current efforts, now commanding millions of research dollars and the full attention of many of our best scientists, will later be exposed as full failures based on false premises?

The textbook writers do not know that attempts to establish a full chronology for all human history (not only to date the creation as a starting point) represented a major effort in seventeenth-century thought. These studies did not slavishly use the Bible, but tried to coordinate the records of all peoples. Moreover, the assumption of biblical inerrancy doesn't give you an immediate and dogmatic answer—for many alternative readings and texts of the Bible exist, and you must struggle to a basis for choice among them. As a primary example, different datings for key events are given in the Septuagint (or Greek Bible, first translated by the Jewish community of Egypt in the third to second centuries B.C. and still used by the Eastern churches) and in the standard Hebrew Bible favored by the Western churches.

Moreover, within assumptions of the methodology, this research tradition had considerable success. Even the extreme values were not very discordant—ranging from a minimum, for the creation of the earth, of 3761 B.C. in the Jewish calendar (still in use) to a maximum of just over 5500 B.C. for the Septuagint. Most calculators had reached a figure very close to Ussher's 4004. The Venerable Bede had estimated 3952 B.C. several centuries before, while J. J. Scaliger, the greatest scholar of the generation just before Ussher, had placed creation at 3950 B.C. Thus, Ussher's 4004 was neither idiosyncratic nor at all unusual; it was, in fact, a fairly conventional estimate developed within a large and active community of scholars. The textbook tradition of Ussher's unique benightedness arises from ignorance of this world, for only Ussher's name survived in the marginal annotations of modern Bibles.

2. The textbook detractors assume that Ussher's effort involved little more than adding up ages and dates given directly in the Old Testament—thus implying that his work was only an accountant's act of simple, thoughtless piety. Another textbook—we are now up to seven—states that Ussher's 4004 was "a date reconstructed from adding up the ages of people named in the lineages of the scripture." But even a cursory look at the Bible clearly shows that no such easy solution is

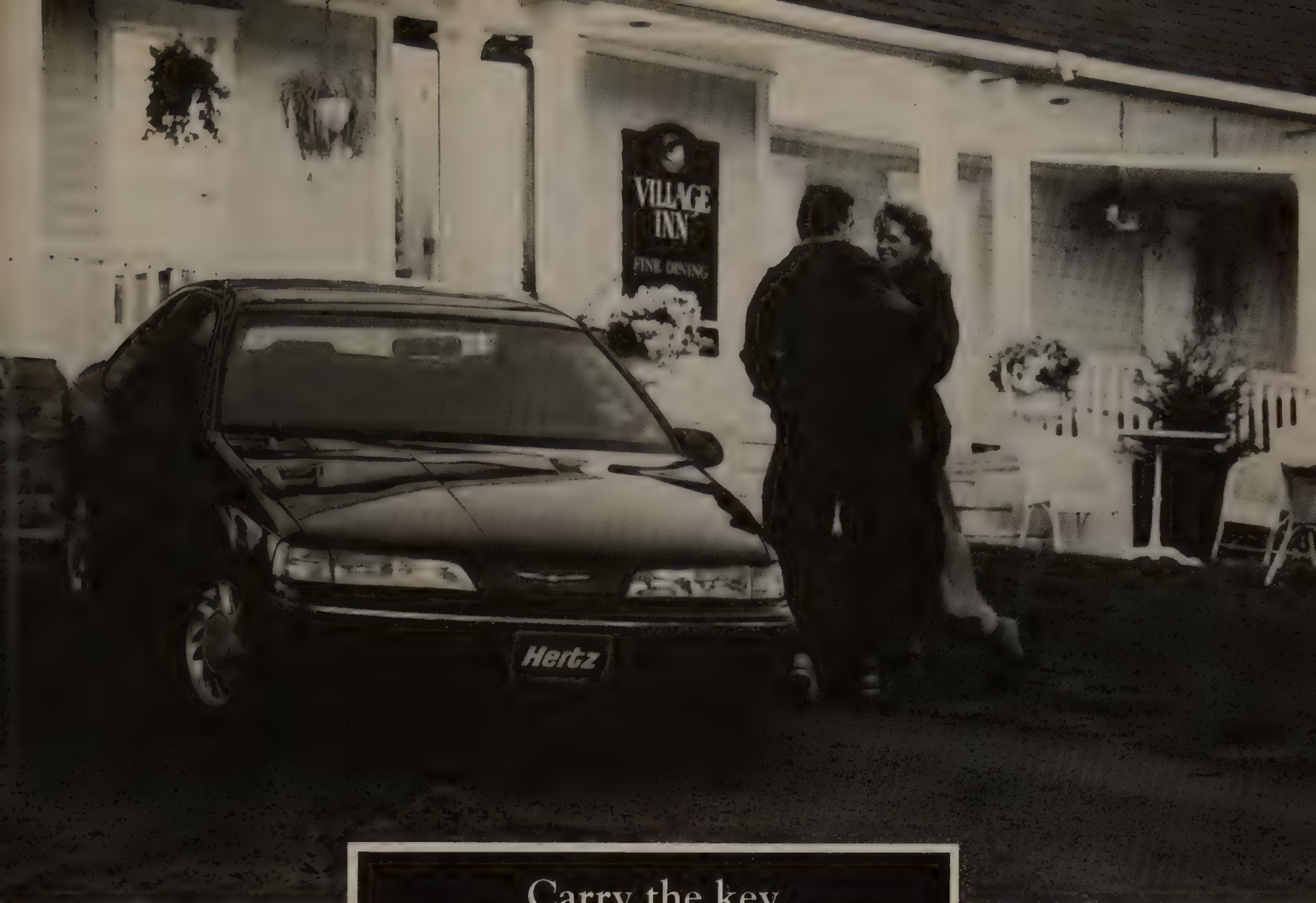
available, even under the assumption of inerrancy. You can add the early times, from creation up to the reign of Solomon—for the requisite information is provided by an unbroken male lineage supplying the key datum of father's age at the birth of a first son. But this easy route cannot be carried forward into the several hundred years of the kingdom, from Solomon's reign to the destruction of the Temple and the Babylonian captivity—for here we are only given the lengths of rule for kings, and several frustrating ambiguities (including overlaps or co-regencies of a king and his successor) were widely acknowledged but not easily resolved. Finally, how can you use the Old Testament to reach the crucial birthday of Christ and thus connect the older narrative to the present? For the Old Testament stops in the period of Ezra and Nehemiah, the fifth century B.C. in Ussher's chronology.

James Barr explains the problems and complexities in an excellent article, "Why the World Was Created in 4004 B.C.: Archbishop Ussher and Biblical Chronology," (*Bulletin of the John Rylands University Library of Manchester*, vol. 67, pp. 575–608). He divides the chronological enterprise into three periods, each with characteristic problems, as mentioned above. You can add up during the first period (creation to Solomon), but which text do you use? The ages in the Septuagint* are substantially longer and add more than 1,000 years to the date of creation. Ussher solved this dilemma by using the Hebrew Bible and ignoring the alternatives.

In the second period, you really have to struggle to establish a coherent time line through the period of the kings. You feint and shift, try to correlate the dates given for the two kingdoms of Israel and Judah, then attempt to link in the few ages given for events other than beginnings and ends of reigns. The result, with luck and adjustment, is a coherent network of mutually supporting times.

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*The name Septuagint derives from the legend that seventy-two translators (close to the Latin *septuaginta*, or "seventy")—six from each of the twelve tribes of Israel—worked in separate rooms and made their own translations. When they compared their results, all were identical. If the linguistic mishmash seems odd—Jews translating the Hebrew Bible into Greek in Egypt—remember that Alexander the Great conquered Egypt and established the Ptolemies as a Greek ruling family.



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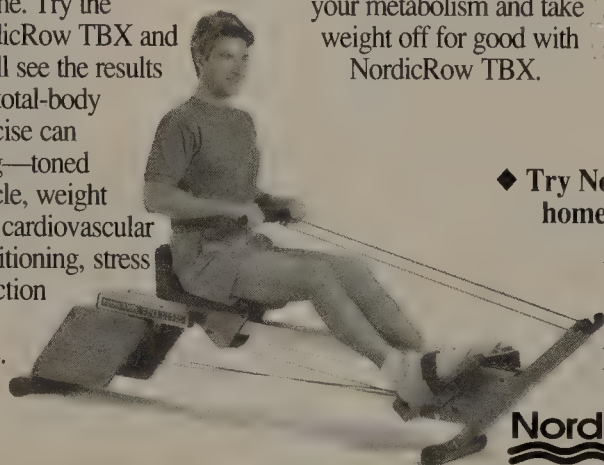
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all—for no information exists. Ussher and all other chronologists therefore tried to link a known event in the period of kings with a datable episode in another culture—and then to use the timetables of other peoples until another lateral feint could be made back into the New Testament. Ussher proceeded by correlating the death of the Chaldean king Nebuchadnezzar II with the thirty-seventh year of the exile of Jehoiachin (as stated in 2 Kings 25:27). (Nebuchadnezzar was, of course, prominent in Jewish history for conquering Jerusalem in 586 B.C. and deporting its prominent citizens—the so-called Babylonian captivity.) Ussher could then calculate through the Chaldean and the subsequent Persian records, eventually reaching the period of Roman rule and the birth of Jesus.

3. But where did Ussher get October 23, 4004? Surely, neither the Bible nor any other source gives a specific date, even if you can estimate the year. Was this date, at least, a bow to dogma, even if the rest of the chronology has more scholarly roots?

No, not dogma, but a different style of interpretive argument—one based on symbol and eschatology rather than on listed chronology. (You cannot label this style as dogma, if only because each point became a subject of lively disagreement and fierce debate among scholars. No resolution was ever obtained, so the church obviously imposed no answer ex cathedra.)

First of all, the date 4004 rests comfortably with the most important of chronological metaphors—the common comparison of the six days of God's creation with 6,000 years for the earth's potential duration: "But, beloved, be not ignorant of this one thing, that one day is with the Lord as a thousand years, and a thousand years as one day" (2 Peter 3:8). Under this widely accepted scheme, the earth was created 4,000 years before the birth of Christ and could endure as much as 2,000 years thereafter (a proposition soon to be tested empirically and, we all hope, roundly disproved!).

But why 4004 and not an even 4000 B.C.? By Ussher's time, chronologists had established an error in the B.C. to A.D. transition, for Herod died in 4 B.C.—and if he truly talked to the Magi, feared the star, and ordered the slaying of the innocents, then Jesus could not have been born after 4 B.C. (an oxymoronic statement, but acceptable as a testimony to increasing knowledge).

Thus, if Jesus was born in 4 B.C., eschatological tradition should fix the date of creation at 4004 B.C., without any need

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for complex, sequential calculation of genealogies. This situation must inspire a nasty suspicion that Ussher "knew" the necessity of 4004 B.C. right from the start and then jiggered the figures around to make everything come out right. Barr, of course, considers this possibility seriously but rejects it for two reasons. First, Ussher's chronology extends out to several volumes and 2,000 pages of text and seems carefully done, without substantial special pleading. Second, the death of Herod in 4 B.C. doesn't establish the birth of Jesus in the same year. Herod became king of Judea (Roman puppet would be more accurate) in 37 B.C.—and Jesus might have been born at other times in this thirty-three-year interval. Moreover, other traditions argued that the 4,000 years would run from creation to Christ's crucifixion, not to his birth—thus extending the possibilities to A.D. 33. By these flexibilities, creation could have been anywhere between 4037 B.C. (4,000 years to the beginning of Herod's reign) and 3967 B.C. (4,000 years to the Crucifixion). Four thousand four is in the right range, but certainly not ordained by symbolic tradition. You still have to calculate.

But what about October 23? Here, chronology cannot help. Many scholars,

from the Venerable Bede to the great astronomer Johannes Kepler, argued for spring as an appropriate season for birth and the chosen time of Babylonian, Chaldean, and other ancient chronologies. Others, including Jerome, Josephus, and Ussher, favored fall, largely because the Jewish year began then, and Hebrew scriptures formed the basis of chronology.

Now an additional problem must be faced. The Jewish chronology is based on lunar months and therefore very hard to correlate with a standard solar calendar. Ussher, recognizing no basis for a firm calibration, therefore decided to establish creation as the first Sunday following the autumnal equinox. (Sunday was an obvious choice, for God created in six days and rested on the seventh, and the Jewish Sabbath comes on Saturday.)

But if creation occurred near the autumnal equinox, why October 23, more than a month from the current date? For this final piece of the puzzle, we need only recognize that Ussher was still using the old Julian (Roman) calendar. The Julian system was very similar to our own, but for one apparently tiny difference—it did not suppress leap years at the century boundaries. (Not everyone knows that our present system—which keeps more accu-

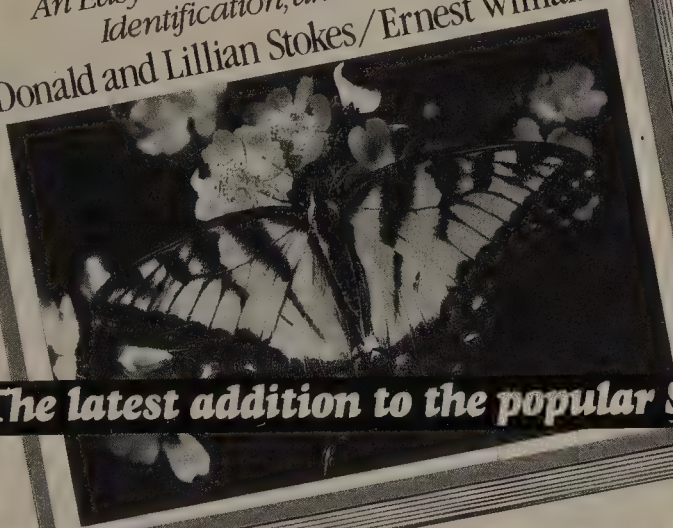
rate time than the Julian—omits leap years at all century transitions not divisible by 400. Thus, 1700, 1800, and 1900 were not leap years, but 1600 was and 2000 will be.) This difference seems tiny, but errors accumulate over millennia. By 1582, the discrepancy had become sufficiently serious that Pope Gregory XIII proclaimed a reform and established the system that we still live by—called, in his honor, the Gregorian calendar. He dropped the ten days that had accumulated from the "extra" leap years at century boundaries in the Julian system (this was done by the clever device of allowing Friday, October 15, to follow Thursday, October 4, in 1582).

We now enter the religious tensions of the time. Recall Ussher's fulminations against popery, an attitude shared by his Anglican brethren in charge. The Gregorian reform smelled like a Romish plot, and Ussher's contemporaries would be damned if they would accept it. (England and the American colonies finally succumbed to rationality and instituted the Gregorian reform in 1752. This delay, by the way, is responsible for the ambiguity in George Washington's birth, sometimes given as February 11 and sometimes as February 22, 1732. He was born under the

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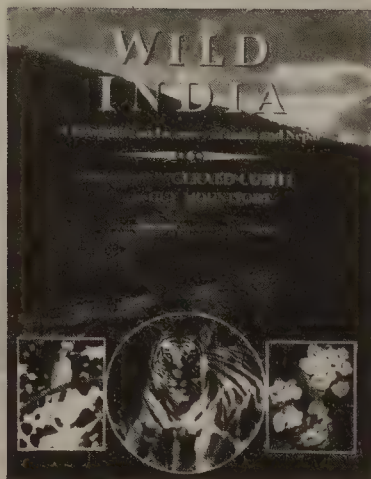
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Julian calendar, and eleven days, rather than ten, had to be dropped by this later time.) In any case, if the Julian discrepancy accounted for ten extra days in the 1,600 or so years between its institution and the Gregorian reform, Ussher realized that the disparity would amount to just over thirty days for the additional time from 4004 B.C.—thus fixing the creation at October 23, rather than about two-thirds through September, as by our present calendar.

One final point. Why high noon on the day of creation? The inception of Genesis reads:

In the beginning God created the heaven and the earth. And the earth was without form, and void; and darkness was upon the face of the deep. And the spirit of God moved upon the face of the waters. And God said, Let there be light. . . .

Now you cannot have days without alternations of light and darkness, so Ussher began chronology with the creation of light, which he fixed, for no given reason, at high noon. He wrote, "In ipse primi diei medio creata est lux" (In the middle of the first day, light was created).

But what about the phrases in Genesis that precede the creation of light? Here is an old exegetical problem: does the text give an epitome of the whole process here, or does it say that God made matter before creating light? Ussher accepted the latter reading and argued that a creation of matter "without form and void" took place during the night before the creation of light. Thus, a precreation, a slipping of material into place, occurred on the night of October 22—yielding several "temporary hours" (Ussher's words) before the overt creation of light on October 23.

4. Ussher's chronology is a work within the generous and liberal tradition of humanistic scholarship, not a restrictive document written to impose authority. As Barr notes, Ussher's *Annales* presents a chronology for all human history (meaning Western history, for he knew no other well enough), from the creation—and you must remember that humans were made five days thereafter, so earthly history is, essentially, human history—to the fall of Jerusalem in A.D. 70. Barr writes:

It is a great mistake, therefore, to suppose that Ussher was simply concerned with working out the date of creation: this can be supposed only by those who have never looked into its pages. . . . The *Annales* are an attempt at a comprehensive chronological synthesis of all known historical knowledge, biblical and classical. . . . Of its volume only perhaps one sixth or less is biblical material.

Socrates told us to know ourselves, and

no datum can be more important for humanism than an accurate chronology serving as a framework for the epic of our cultures, our strivings, our failures, and our hopes.

The figure of Ussher that begins this article comes from the only work of his that I own—a comprehensive catechism prepared for children and their families, entitled *A body of divinity: or, the sum and substance of Christian religion*. Catechisms may simplify, but they have the virtue of laying basic belief right on the line, without the hemming and hedging so intrinsic to academic texts.

I was delighted by Ussher's defense of his chronology in this catechism—simple words that illustrate the basic humanism of his enterprise. How do we know about creation, he asks—and responds: "Not only by the plain and manifold testimonies of Holy Scripture, but also by light of reason well directed." His main quarrel, we note, is not with other timings of the human epic, but with Aristotle's ahistorical notion of eternity. "What say you then to Aristotle, accounted of so many the Prince of Philosophers; who laboreth to prove that the world is eternal." Ussher answers his own question by defending God's majesty against a mere unmoved mover of eternal matter, for Aristotle "spoileth God of the glory of his Creation, but also assigneth him to no higher office than is the moving of the spheres, whereunto he bindeth him more like to a servant than a lord."

I close with a final plea for judging people by their own criteria, not by later standards that they couldn't possibly know or assess. We castigate Ussher for making the creation so short—a mere six days, where we reckon billions for evolution. But Ussher fears that six days might seem too long in the opinion of his contemporaries, for why should God, who could do all in an instant, so spread out his work? "Why was he creating so long, seeing he could have perfected all the creatures at once and in a moment?" Ussher gives a list of answers, but one caught my attention both for its charm and for its incisive statement about the need for sequential order in teaching—as good a rationale as one could ever devise for working out a chronology in the first place! "To teach us the better to understand their workmanship; even as a man which will teach a child in the frame of a letter, will first teach him one line of the letter, and not the whole letter together."

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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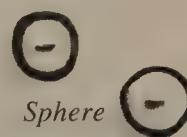
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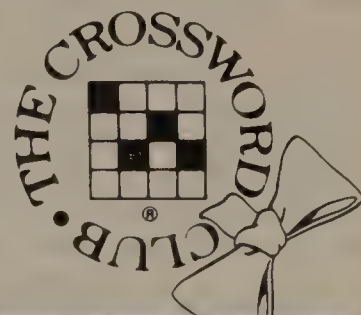
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Pilgrims' Paradox

Thanksgiving is in the eye of the beholder

by Samuel M. Wilson

December 22 will mark 110 years since Mark Twain addressed the Sons of New-England in Philadelphia. "I rise to protest," he began. "I have kept still for years, but really I think there is no sufficient justification for this sort of thing. What do you want to celebrate those people for?—those ancestors of yours, of 1620—the Mayflower tribe, I mean." Mixing social critique with humor, Twain alluded to the Pilgrims' prejudices: "Your ancestors—yes, they were a hard lot; but, nevertheless, they gave us religious liberty to worship as they required us to worship, and political liberty to vote as the Church required." Portraying himself, as he often did, as a composite of the whole human race, "an infinitely shaded and exquisite mongrel," he asked, "Where are my ancestors? Whom shall I celebrate? Where shall I find the raw material? My first American ancestor . . . was an Indian; an early Indian; your ancestors skinned him alive, and I am an orphan" (*New York Times*, December 26, 1881).

Thanksgiving is a holiday built around a story: The Pilgrims, fleeing religious persecution, sailed from England to the New World aboard the *Mayflower*. They stepped ashore on Plymouth Rock and began a new colony. In unfamiliar territory, they came near starvation, but the Indian Squanto appeared and taught them to plant corn and make their living from the land. Led by William Bradford and Miles Standish, they survived these difficult early days, and when they brought in the first rich harvest, they set aside a day to give thanks to God for their good fortune. The chief Massasoit and

their other Native American neighbors came bringing deer and wild turkeys, and together the Indians and the Pilgrims celebrated the first Thanksgiving.

The vague history (more myth, really) of the first Thanksgiving presents a scenario of the encounter of New World and Old World people that existed for only a moment, if it existed at all. It involves one of the least typical, and least successful, groups of European colonizers of the North American continent. Yet Thanksgiving is an important celebration throughout the United States, and like most things central to American culture, it is complicated and multilayered.

The historical trail of the first Thanksgiving begins (and practically ends) with a quotation from a letter by Edward Winslow written on December 11, 1621:

Our harvest being gotten in, our Governour [William Bradford] sent foure men on fowling, that so we might after a more speciall manner rejoyce together, after we had gathered the fruit of our labours; they foure in one day killed as much fowle, as with a little helpe beside, served the Company almost a week, at which time amongst other Recreations, we exercised our Armes, many of the Indians coming amongst us, and amongst the rest their greatest King Massasoit, with some nintie men, whom for three dayes we entertained and feasted, and they went out and killed five Deere, which they brought to the Plantation and bestowed on our Governour, and upon the Captaine [Miles Standish], and others. And although it be not alwayes so plentifull, as it was at this time with us, yet by the goodnesse of God, we are so farre from want, that we often with you partakes of our plentie. We have found the Indians very

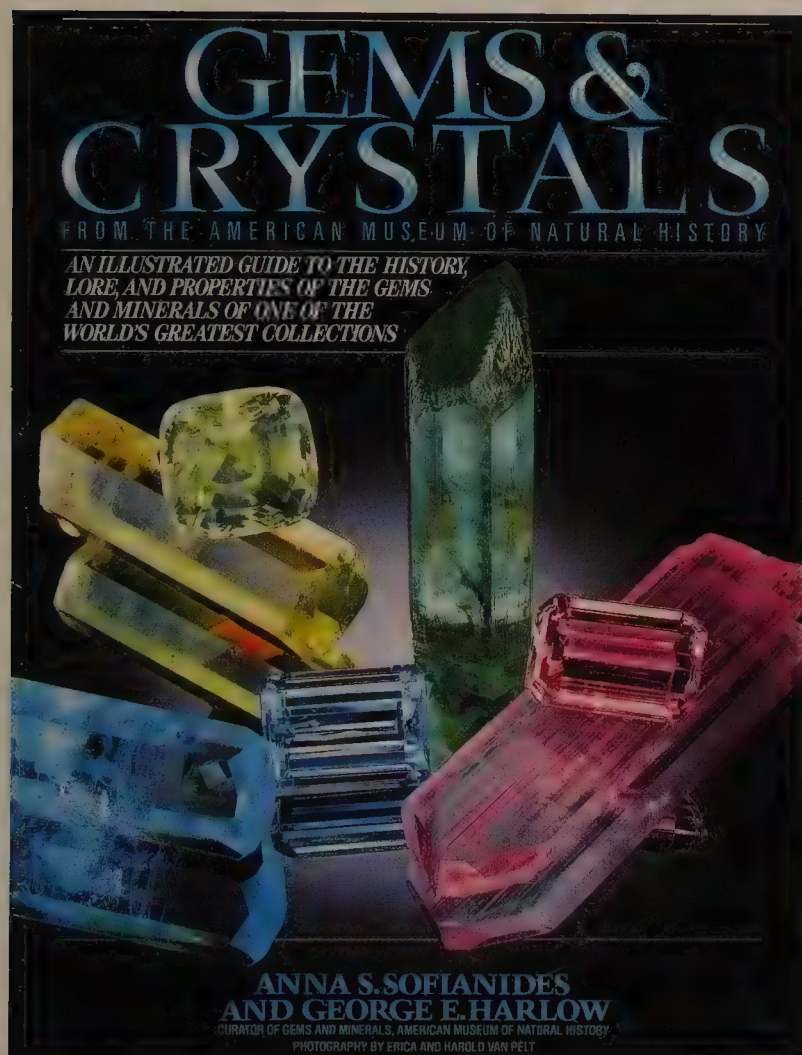
faithfull in their Covenant of Peace with us; very loving and readie to pleasure us: we often goe to them, and they come to us; some of us have bin fiftie myles by Land in the Country with them [*A Relation or Journall of the Beginning and Proceedings of the English Plantation Settled at Plimoth in New England*].

Even less is revealed in Bradford's *Of Plimoth Plantation*. He does not mention Massasoit's three-day visit or express any special sense of thanksgiving. In his notes from about September 1621, he simply says that "besides waterfowl there was a great store of wild turkeys, of which they took many, besides venison, etc. Besides they had about a peck a meal a week to a person, or now since harvest, Indian corn to that proportion."

The origin of Thanksgiving as a national holiday is even more ambiguous. In *The Fast and Thanksgiving Days of New England* (1895), W. DeLoss Love records 696 New England observances of days of thanksgiving in the seventeenth century alone and laments the inadequacy of the archives. The dates fall nearly without pattern, on any day in any month. In 1879, the Reverend I. N. Tarbox looked for the origin of the holiday in his article "Our New England Thanksgiving, Historically Considered" (*The New Englander*, March 1879). He concluded:

The lesson to be learned from the survey thus made is, that Thanksgiving as we now have it, is the slow growth of many years. It did not come into the full strength of its existence in New England until after the close of the seventeenth century. For more than eighty years after the Pilgrims landed at Plymouth it was more or less miscella-

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neous in its order, and its times, and in its
character.

Tarbox thought that the holiday had
deeper Judeo-Christian roots, which he
found in the Old Testament Feast of Tab-
ernacles—"the feast of the harvest, the
first fruits of thy labours, which thou has
sown in the field; and the feast of in-gath-
ering, which is in the end of the year when
thou has gathered." The Bible instructed,
"Ye shall rejoice before the Lord your
God seven days."

George Washington declared February
19, 1795, to be a national Thanksgiving
day, celebrating the suppression of the
Whiskey Rebellion. He had proclaimed
one earlier to mark the ratification of the
Constitution, but both of these were one-
time events. John Adams favored a more
permanent holiday on May 9. Thomas Jef-
ferson objected to the whole undertaking:
setting days of fasting and prayer was a
religious matter, he argued, not the busi-
ness of government. Many other Thanks-
givings were proclaimed to observe a vari-
ety of military victories, but no regular
national holiday was set. Throughout the
early nineteenth century, a federal policy
evolved of leaving the matter to the indi-
vidual states.

Finally, after the battle of Gettysburg,
Lincoln moved to proclaim a national day
of Thanksgiving. Initially the holiday was
set for August 6, but Sara Joseph Hale,
editor of *Godey's Lady's Book*, and Secre-
tary of State William Seward persuaded
Lincoln to change the date to encompass
the harvest festival traditions of many
New England states. Lincoln proclaimed,
"I do, therefore, invite my fellow citizens
in every part of the United States... to
set apart and observe the last Thursday of
November next as a day of thanksgiving
and praise to our beneficent Father who
dwelleth in the heavens." Lincoln was
building bridges and seeking to emphasize
common traditions in "every part" of a
nation splintered by war. Thanksgiving,
an ambiguous, multi-purpose holiday, was
ideal for this purpose.

So the Pilgrims had little to do with the
institutionalization of the present national
holiday. And perhaps properly so. As colo-
nists the Pilgrims were about the least
successful on record if a colony's success is
measured by growth. The people of Ply-
mouth Colony were ultimately attracted
to other, more dynamic centers, leaving
their settlement and church, in Bradford's
words, "like an ancient mother grown old,
and forsaken of her children."

Kenneth Davies, in *The North Atlantic
World in the Seventeenth Century* (Uni-
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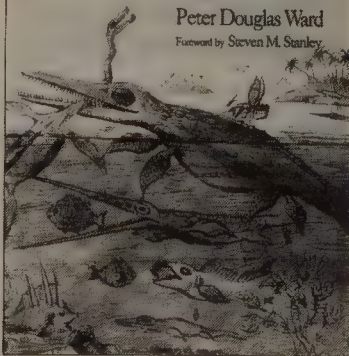
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scribes the Pilgrims' colonial enterprise bluntly, calling them, "a settlement of exiles and drop-outs who entered a plantation covenant to walk in the same way. They had no royal charter, no authorizing act from a parent colony, no proprietorial sponsor, and no mercantile backing. They were squatters." Even Thoreau, in his *Cape Cod*, apologizes for the Pilgrims: "It must be confessed that the Pilgrims possessed but few of the qualities of the modern pioneer. They were not the ancestors of the American backwoodsmen."

And yet, the first Thanksgiving became the centerpiece of the national holiday. Perhaps this is because the story of the Pilgrims could be molded into a variety of forms, embellished and retold in order to make different points or emphasize different values or principles.

Daniel Webster saw the Pilgrims as the founders of a new and democratic political order based on religious principles. In his address on Forefathers' Day in 1820, he creatively rewrote the speech delivered on the Pilgrims' landing: "If God prosper us, we shall here begin a work which shall last for ages. We shall plant here a new society, in the principles of the fullest liberty, and the purest religion; . . . the temples of the true God shall rise, where now ascends the smoke of idolatrous sacrifice" (*A Discourse, Delivered at Plymouth, December 22, 1820*).

In the political interpretation of the story, the Pilgrims represent the seed of democracy in the New World. In this view, the Mayflower Compact—a modest and impromptu statement at best—is presented as the model and inspiration for later democratic charters, including the United States Constitution. It was actually a short and rather vague document that no modern lawyer would touch. It comprised only five sentences, the essence of which is that

[We] in the presence of God and one of another, covenant, and combine our selves together into a civill body politike, for our better ordering and preservation, and furtherance of the ends aforesaid; and by vertue hereof to enact, constitute, and frame such just and equall Lawes, Ordinances, acts, constitutions, offices from time to time, as shall be thought most meet and convenient for the generall good of the Colony: unto which we promise all due submission and obedience [*A Relation . . . of the English Plantation Settled at Plimoth in New England*].

The story of the Pilgrims has also been scripted as an epic romance, an early American version of Arthurian legend. Henry Wadsworth Longfellow's *The Courtship of Miles Standish* (1858) and Jane G. Austin's *Standish of Standish*

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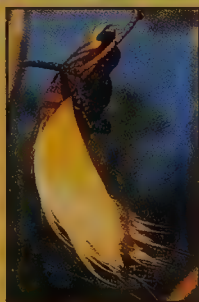
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(1889) develop the romantic theme. In her preface, Austin sets the tone for her heroic tale, which bears almost no relation to the recorded history of the Plymouth Colony: "I offer this story of Myles Standish, The-Sword, the hero, who not for gain, not from necessity, not even from religious zeal, but purely in the knightly fervor of his blood, forsook home, and heritage, and glory, and ambition, to accompany that helpless band of exiles, and to be the Great-Heart of their Pilgrimage to the City that they sought."

Austin's is a melodramatic love story featuring Standish, John Alden, and Priscilla Moline. The Indians appear only briefly, announced by "The fiend is upon us!" and figuring as devious villains that Standish must overcome.

The story of the first Thanksgiving is also a parable about Indian-white relations. The late Lynn Ceci, an archeologist and ethnohistorian of the Northeast, in a fascinating article entitled "Squanto and the Pilgrims" (*Society*, May-June 1990; her article prompted this essay) gently debunks the story that Squanto, the Indian guide and interpreter, taught the Pilgrims to fertilize their corn with fish (a practice that she found to be of European origin). Ceci proceeds to unravel large sections of the fabric of the first Thanksgiving story.

In particular, Ceci reveals Squanto to be a much more complex and interesting person than the "noble savage" often portrayed. The simplistic view of Squanto, like that of many Indians in European-American folk tales, was of a person with no history. He helped the Pilgrims because of his friendly nature. For example, in Wilma Pitchford Hays's story for children "Paying for Indian Corn" (*Jack and Jill*, 1958), "Squanto had learned a little English from fishermen whose ships had stopped in the New World."

In fact, Squanto had been kidnapped from Cape Cod and sold into slavery in Spain in 1614, six years before the Pilgrims sailed. He may have returned to Cape Cod a year later with Capt. John Smith (if "Tantum" on Smith's manifest is Squanto), but in any case, he eventually made his way to England, where he lived with the treasurer of the Newfoundland Company. He then accompanied Capt. John Mason to Newfoundland in 1617 (listed as "Tasquantum") and returned to England with Capt. Thomas Dermer in 1618. Finally returning to New England with Dermer, he left the ship to rejoin his people, the Patuxet. Finding that none remained (all had been taken as slaves or had died of European diseases), he stayed with the Pilgrims as guide and interpreter.

According to Bradford, Squanto

sought his own ends and played his own game, . . . putting the Indians in fear and drawing gifts from them to enrich himself, making them believe he could stir up war against whom he would, and make peace for whom he would. Yea, he made [the Indians] believe [the English] kept the plague buried in the ground, and could send it amongst whom they would, which did much to terrify the Indians and made them depend more on him, and seek more to him, than to Massasoit.

In 1622, again according to Bradford, "Squanto fell sick of an Indian fever, bleeding much at the nose (which the Indians take for a symptom of death) and within a few days died there."

Ceci describes Squanto as an

enterprising survivor and culture-broker who facilitated the meshing of disparate cultures on a new frontier. More importantly, the invented Squanto masks the more threatening and numerous Indians of the frontier period who, objecting to the usurpation and invasion of their lands, attacked and killed settlers—a more accurate representation but a history too uncomfortable for popular American consumption.

Twenty-two years ago in these pages, historical archeologist James Deetz described the Pilgrims as more medieval than modern, "a culture as different from that of Americans today as are many cultures of modern Africa or Latin America" ("The Reality of the Pilgrim Fathers," *Natural History*, November 1969). The feast of Thanksgiving celebrated this month is a phenomenon of our time, not theirs, a morality tale dealing with values central to modern American culture—religious freedom, self-reliance, political independence, and racial harmony.

At the end of his speech a century ago, Mark Twain teased Philadelphia's society of the Sons of New-England for making heroes of their Puritan ancestors:

Hear me, I beseech you; get up an auction and sell Plymouth Rock! The pilgrims were a simple and ignorant race; they never had seen any good rocks before, or at least any that were not watched, and so they were excusable for hopping ashore in frantic delight and clapping an iron fence around this one. . . . Disband these societies, hotbeds of vice, of moral decay; perpetuators of ancestral superstition. Here on this board I see water. I see milk. I see the wild and deadly lemonade. These are but steps upon the downward path. Next we shall see tea, then chocolate, then coffee—hotel coffee. A few more years—all too few, I fear—mark my words, we shall have cider! Gentlemen, pause ere it be too late.

Samuel M. Wilson teaches anthropology at the University of Texas at Austin.

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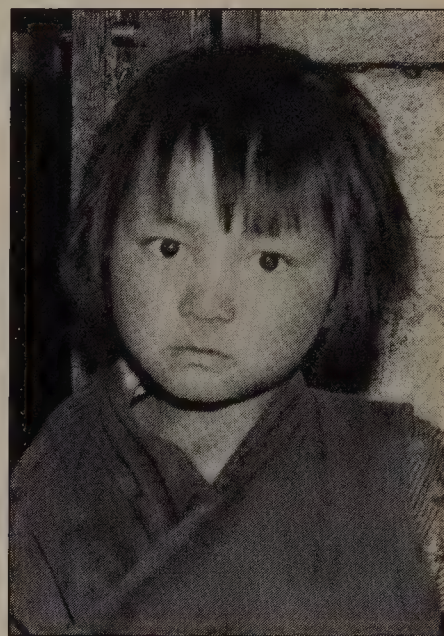
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Hope and Glory

Don't knock the humble horoscope

by Roger L. Welsch

Great. It's November and my birthday is in November. But you probably know that already. If you are at all perceptive, you've already noticed that I'm a Scorpio—mercurial, sensitive, caring, curious, adventurous, well liked, hungry.

We live on a Nebraska farm under some very active airplanes. I suspect that's because at any given time there are more people flying over Nebraska than there are in it. And most Nebraskans prefer it that way. The consequence of all that air traffic, however, is that I can never get a straight shot at a horoscope reading, because whatever is transcending my sign, however Saturn is conjuncting with Aries, whatever sign Jupiter happens to be intersecting, more often than not an airplane contrail is transecting the whole mess.

Yes, I'm talking astrology here, one of the most abused systems of general encouragement we have these days. Horoscopes are always encouraging. My horoscope never says, "Later today there's a good chance you're going to die, you broody Scorp" or "Expect a subpoena today, you mercurial boob." My horoscopes always say nice things. "A good day to renew old friendships and take a chance on a financial risk" or "With any luck, today is the day your wildest dream may come true," with only now and then a hint of the darker side of life: "Be cautious about a possible romantic connection with a Pisces." (Come to think of it, maybe that's one of the most encouraging readings I've had recently.)

Nancy Reagan used an astrologer to determine the president's schedule, and right away everyone got indignant. I think that with the job of president being as tough as it is, any sort of cheer we can throw that way is worth the inconvenience to the pilot of Air Force One. "Today is a good day to consider stemming nuclear proliferation, but use some caution in affairs of the economy" or "Be nice to a

Democratic senator today, and he or she may be nice to you tomorrow." That sort of encouragement can't hurt.

Fortune cookies aren't exactly astrology, but they haven't helped the situation. Fortune cookie fortunes have declined in quality and courage, even within my own decades of chopsticking. I distinctly remember fortune cookies that warned against specific enemies and promised precise rewards ("Wash your car this afternoon and a pretty girl named Bernice will smile at you"), while today there are only bland vagaries ("Be nice and work hard and good fortune will be yours").

Back in the good ol' days of no-holds-barred fortune cookies, I was dining in a Chinese restaurant with an attractive young woman—catch me sometime without my wife, Linda, and I'll tell you who she was—and my fortune cookie said, "Tonight is the night for love and romance," which struck me as pretty specific, considering the circumstances. I tucked the little slip of paper with the optimistic fortune into my billfold and forgot about it (and, as a matter of fact, its accuracy or inaccuracy) and discovered it only four or five years later. My son gave me a new wallet for Christmas and I was cleaning out the old one. I noticed that years before I had tucked the promising fortune cookie paper into the plastic sleeve in which I also carried my faculty identification card. The card I showed once a month to the young woman who handed out our salary checks.

So, as I came to realize, once a month I smiled at this young woman, said my name, asked for my check, and flashed her a slip of paper saying, "Tonight is the night for love and romance." You cannot imagine how many indignant looks my discovery explained.

Maybe it's Chinese restaurants rather than fortune cookies that have given the public the wrong idea about mystical de-

vices. I haven't had much luck in general in Chinese restaurants. We frequent a terrific one called Yen Ching, where at each diner's place there is a paper place mat with a system for figuring out which Chinese sign you fall under and what that means for your life.

I have my doubts about whether this is a good idea, because the Chinese don't have charming and romantic signs like Libra, Pisces, and Virgo. No, depending on which year you were born, in China you are a horse, rat, pig, or any of several other creatures you'd just as soon not think about right before supper. If it hadn't been for some great moo shu pork, finding out that I am a rat probably would have taken the edge off supper for me.

As it turned out, however, that was the least of my problems, because my wife, Linda, calculated that she is a horse. I probably could have smoothed that over by conjuring up visions of Black Beauty and other spirited, slim, and magnificent steeds, but the clincher was that our place mats told us that rats and horses are not compatible signs, which has put considerable strain on our ten-year marriage, as you can imagine.

My sense is that the most indignant protestors against astrology don't even read their horoscopes. That's the only thing I can think of that would generate such negativism. Here's a horoscope I got last year in a little pulp book that summarized the upcoming year for me:

Scorpio: this is your year! Brace yourself for some of the recognition you have deserved but which is, as you know, long overdue. The clouds that afflicted your life and darkened your cosmic lamp will blow away and members of the opposite sex will suddenly discover the fire that burns within you. This would be a good year to work extra hard because someone out there is watching you and only needs a little more evidence before catapulting you high into the celestial orbit for which you were meant. This year look

forward to unexpected financial gain. Your striking voice and one-of-a-kind personality combine to open new doors for you in business. Good fortune is at last yours. Smile, Scorp-blaster! The world will never be the same.

That particular horoscope was projected by a mystic named Ruth de la Astralo, which should suggest to anyone with any sense at all that this woman was born to the task of casting horoscopes, and anyone in town will tell you, de la Astralo couldn't possibly have been that accurate without somehow knowing me and my karma perfectly. I mean, really: "striking voice," "one-of-a-kind personality," "long overdue," "burns within you!" This woman knows me as if she were my sister, if I had a sister, although we have never met. Absolutely uncanny!

Scoff if you will, but I decided to test Ms. de la Astralo's predictions: I kept track of what happened to me last year. The results were astonishing. Last year was the year I made it to the next to final stage of the Publishers' Clearing House sweepstakes (the level at which the envelopes carrying announcements of your progression through the selection system no longer come by bulk mail). I got the chance to write this column in *Natural History* this May, close enough to last year to fulfill the "celestial orbit for which [I] was meant" clause. At a farm auction I got a nearly new log chain for three dollars—a fraction of its value and a response to my striking voice—an unexpected financial gain if I ever saw one. And I didn't break my foot until the last day of the year, close enough to this year that I think of it as "good fortune" for last year.

You wanted evidence, scoffer? There it is. And of all places, in the pages of *Natural History* magazine!

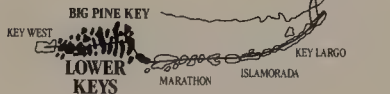
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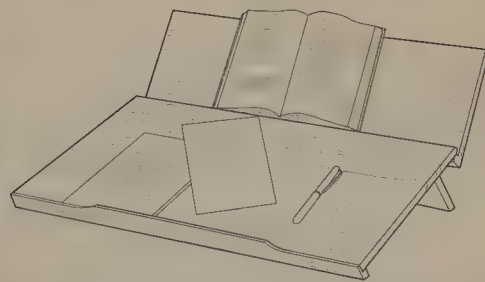
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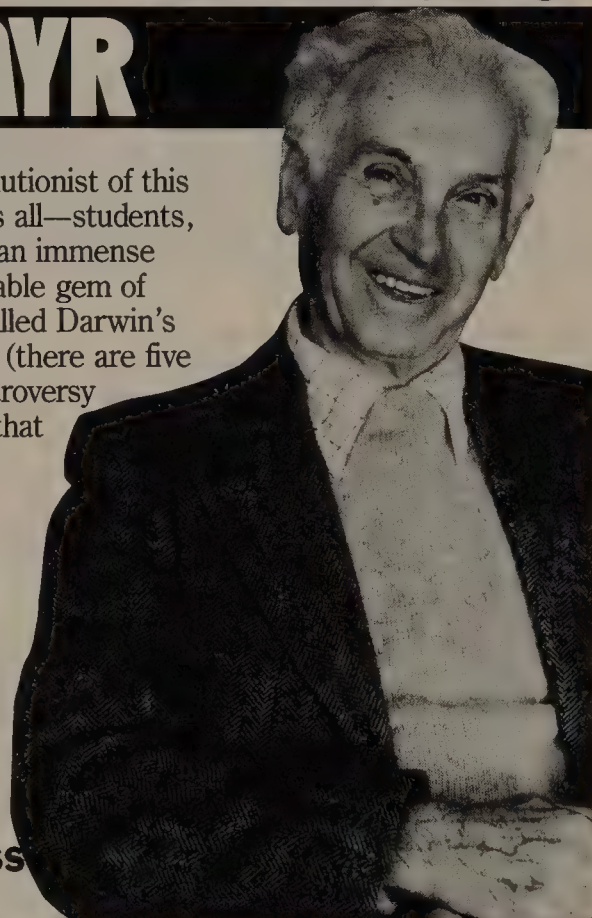
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Post Office Bay, Florida

by Robert H. Mohlenbrock



"These are the crown jewels of the pineland wet savannas in North America," remarked Steve Orzell as he, Edwin Bridges, and I drove through the Florida Panhandle southwest of Tallahassee, observing large expanses of grassland that intruded like fingers into the forests of longleaf pines. Orzell and Bridges, a pair of dedicated Florida botanists, had been studying the ecology and plant diversity of these wet savannas and were eager to introduce me to the different types found in a part of the Apalachicola National Forest known as Post Office Bay.

The savannas and their surroundings appear nearly flat, but there are slight differences in elevation that enable distinct plant communities to develop. At the

higher and drier end of the spectrum is a forest dominated by longleaf pines, with a dense, often impenetrable undergrowth of saw palmettos. As the elevation drops ever so slightly (the gradient is seldom more than 6 feet over a distance of 600 feet), the pines suddenly drop out and the wet savanna begins, dominated by grasses and sedges growing in saturated or mucky soils. Deeper into the savanna more surface water accumulates; when it reaches a depth of perhaps eight to twelve inches, the savanna ends and a swampy zone of two- to three-foot-tall, water-tolerant shrubs appears.

Where the standing water is between one to three feet deep are stands of ascending pond cypresses, known as cypress

domes. The border of a cypress dome consists of two species of St.-John's-worts, six-foot-tall shrubs with needlelike leaves. One of these, which grows in slightly deeper water than the other, has an inch-thick layer of tightly compressed, papery, reddish bark that protects the shrub from fire. A shrubby black gum that is found nowhere else sometimes grows in the cypress dome.

Although wire grass, a very narrow-leaved grass, dominates all the savanna areas, there are actually two types of wet savannas. Botanist Andre Clewell noted this some years ago, calling them the *Verbesina* Phase Savanna and the *Pilea* Phase Savanna, based on the characteristic flower that grows in each.

Water-tolerant shrubs grow near the edge of one of Post Office Bay's Pleea Phase savannas.

Todd Bertolaet



The Verbesina Phase Savanna occupies soils topped by as much as eight inches of clay. The surface consists of a hardpan, or hardened layer, that is nearly impermeable to water. Water stands on the hardpan throughout the wetter seasons of the year, mixing with the clay to form a black, sticky muck. The verbesina, or crown-beard, which gives this savanna its name, is unique to the Florida Panhandle. Its numerous round heads of yellow, tubular flowers grow at the tips of three-foot-long branches. Carnivorous plants also prosper here—sundews (a tiny one with yellow flowers and one that grows up to ten inches tall with inch-wide purple flowers); the tall yellow pitcher plant and the lower-growing red pitcher plant; and two kinds

of butterworts, plants that entrap insects in their leaves. Other common plants are two kinds of lady's hats, with their solitary white flowering heads perched atop needlelike stems, and a diversity of sedges known as beaked rushes and nut rushes.

Rarities found in the verbesina savanna include the grass-leaved black-eyed Susan, which has maroon flower heads; a large, blue-flowered skullcap of the mint family; and a foot-tall sunflower whose only leaves are crowded at the base of the plant. The round-toothed milkwort is a plant whose seeds are produced from underground flowers: one advantage of this form of reproduction is that the flowers and seeds are safe from fire.

In the Pleea Phase Savanna the soil is a

sandy loam instead of clay. Although water from the adjacent longleaf pine forests continually drains through the sand, the water table is high: if one presses a foot down hard, water will gurgle up a few inches away. *Pleea*, or rush featherling, is always common here. A member of the lily family, it has small white flowers and its leaves resemble those of an iris. Species associated with it include pitcher plants, sundews, and bladderworts. Also carnivorous, bladderworts have small bladders; attached to an intricate stem system below the water, these bladders can suck in microscopic insects.

The wet savannas of Post Office Bay are not a stable community. Their health and vigor often depend on the amount of



Post Office Bay

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rainfall received during the year. Periods of drought lower the water table, with the result that some species fail to flower or even to come up. Fires are also essential to the savanna ecology. The savannas in Apalachicola National Forest are now deliberately burned every three to five years, usually in April after plant growth has resumed. The fires are often set to include the adjacent longleaf pine forests and are allowed to spread across the savannas, burning out naturally in the deeper water.

In the longleaf pine forests, fire knocks back the dense growth of saw palmettos. During the first year following a burn, wire grass takes over beneath the pines, forming a continuous, light green cover. Eventually the saw palmettos regain their prominence in the understory.

April fires burn well in the wet savannas, despite the seepage water overlying the clay and saturating the sandy loam. Fire kills such woody plants as titi and inkberry, which otherwise tend to displace more fragile species. An April burn compresses the flowering season, with species that normally bloom in April and May delaying their flowering until summer and autumn, joining the species that normally bloom then. With more than 100 species of plants bursting into flower, these areas provide a profusion of color. Wire grass, the dominant species of the wet savannas, blooms vigorously following a burn, but otherwise may not.

As it burns toward the deeper waters of a cypress dome, the fire begins to die out. The shrubby St.-John's-words, with their thick layers of bark, remain unharmed, but the cypresses on the periphery will be singed and their growth will be retarded for a while. The cypress trees in the center of the dome usually remain unscathed. The resultant layered effect—with six-foot St.-John's-words; stunted, ten- to twelve-foot cypresses; and forty- to fifty-foot cypresses—gives the cypress dome its rounded shape.

"This Land" explores the biological and geological highlights of the 156 U. S. national forests. Robert H. Mohlenbrock is Visiting Distinguished Professor of Plant Biology at Southern Illinois University at Carbondale.



Sunrise pierces the longleaf pines.

John Palis



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An alert long-tailed weasel momentarily pauses during its afternoon rodent hunt near the edge of Loon Lake, Wyoming.

Michael S. Quinton

Weasel Roulette

Life for these fierce, pint-size predators is a deadly serious game of risk and reward

by Carolyn M. King

One fine day in 1953, a Mr. C. Barrow was taking a stroll along a lakeshore in the English countryside when he noticed a large moorhen flying overhead. Its flight was labored and awkward, and there seemed to be something brown hanging around its neck. To his astonishment, Barrow saw that the something was a weasel, its jaws buried in the bird's chest and all four sets of claws clinging to the feathers. Eventually, the desperate bird dived into deep water, taking the weasel with it.

Some years later, another British observer named Anderson witnessed a buzzard, or European hawk, swoop down, pick up a weasel from the ground, and then fly off to its usual feeding perch. But within seconds the buzzard's smooth flight turned into an ungainly struggle, and it eventually fell to the ground. Anderson ran to where it fell, and there was the buzzard lying dead on the ground, its underparts bloody, and the weasel still gripping its breast with meshed teeth.

These two eyewitness accounts were published in natural history journals; there is also a documented case of an eagle that survived a similar encounter—but thereafter carried a weasel's bleached skull with clenched jaws fixed to its neck.

These three weasels took their chances when they could, but two of them lost the gamble. Their stories illustrate the two most important facts about weasels; they are small in body size, rarely exceeding twelve ounces in weight and sixteen inches in length, yet they are also fierce carnivores with a confidence and audacity out of all proportion to their stature. Nearly all the curious facts about these intriguing little animals can be traced back to the contradictions between the risks and rewards of being a small hunter and to the unpredictable way that chance affects the balance between them.

For example, weasels are small enough to be mistaken for prey by foxes, cats, hawks, and owls, which means that they are always at risk of attack, but they are also fully capable of holding their own against these much more powerful assailants. On the other hand, the weasels' small size gives them, alone among all warm-blooded predators, the ability to follow rodents down their burrows and into their nests. This is a huge advantage, well worth the risk of the hunter becoming the hunted. Rodents have no defense against a predator that can seek them out in their last refuges and clean out whole litters of nestlings, by day or by night. By contrast, larger predators can catch only those rodents that venture out from under thick cover.

There are three kinds of weasels in the Northern Hemisphere, although most places have only two. They are the long-tailed weasel (*Mustela frenata*); the short-tailed weasel, also called the ermine or stoat (*M. erminea*); and the least, or common, weasel (*M. nivalis*). All weasels prefer to hunt small mammals, especially voles and lemmings, but these are unreliable prey, and in some years they virtually disappear (see "The Lemming Phenomenon," by Lennart Hansson, *Natural History*, December 1989). So when hungry, weasels will tackle prey much larger than themselves. Of course they are careful when they can be because the danger is real for a weasel that miscalculates; an enraged doe rabbit with young to protect is a truly formidable adversary to a stoat, and so is a hefty lemming to a least weasel. In 1987 Canadian naturalist Alton S. Harestad observed a long-tailed weasel being mobbed by two ground squirrels when it attempted to attack a third. The weasel fled. Zoologist Durward Allen once placed cottontail rabbits in enclo-

tures with long-tailed weasels: four times a weasel killed a rabbit, and four times a rabbit killed a weasel.

Just as a zebra can injure a lion, so too a vole can injure a weasel; as a result, weasels have become good at sizing up their chances, recognizing whether or not the odds favor them, and quick to react either way. Normally, they attack only when opportunity offers them an edge, especially when they are not particularly hungry. But, as one experienced observer of weasels puts it, when the chips are down and the choice is to take a chance or starve, they will bet their lives on success in the hunt.

Nature tends to be unsympathetic to animals that take too many chances, so the question is, how can weasels survive if being a small predator is such a dangerous business? The answer seems to be that being small brings rewards that outweigh the risks. Small size increases a weasel's opportunity to find a meal faster than it increases its risks of becoming one.

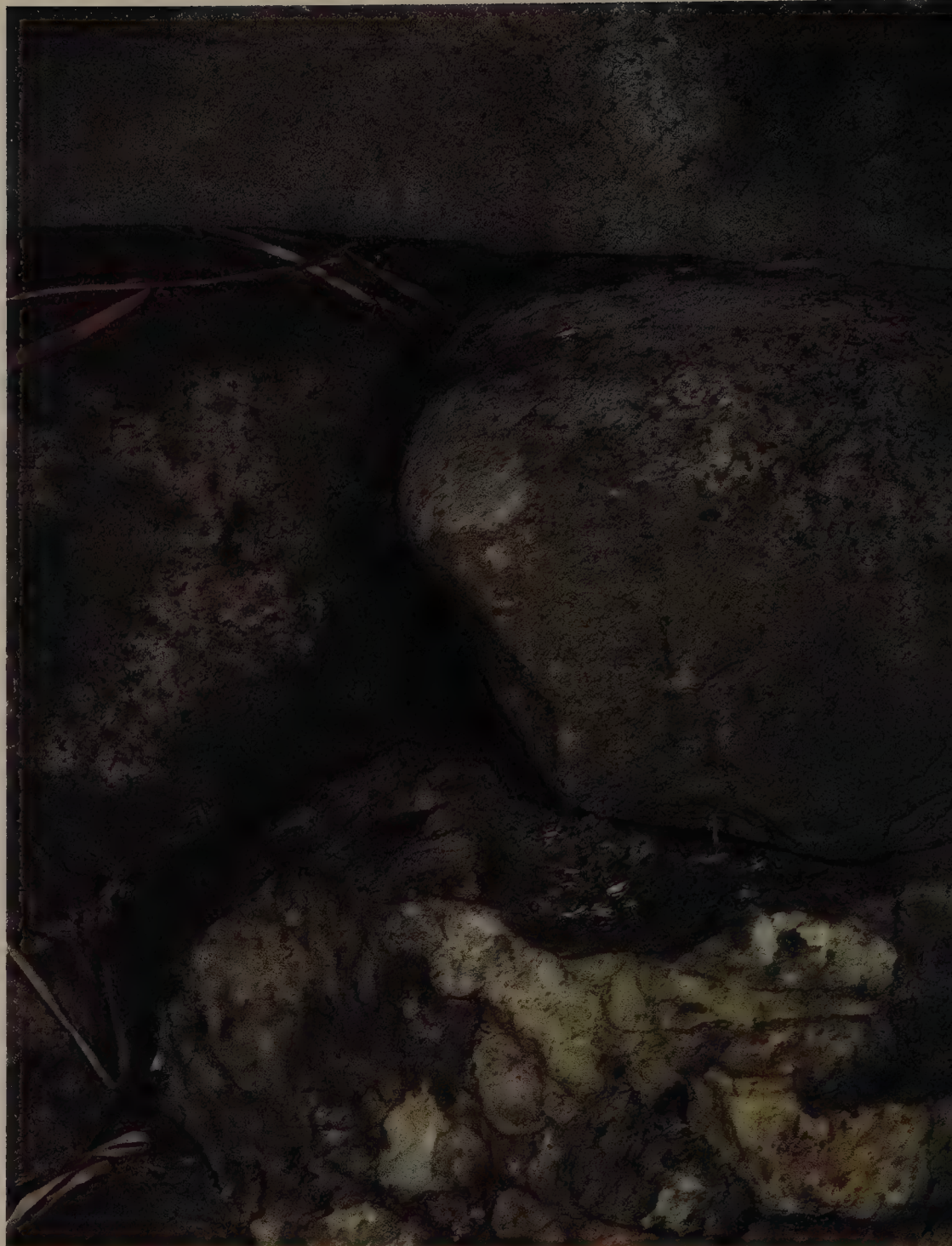
A hunter small enough to enter a rodent burrow must still be strong enough to attack and kill. Weasels make up in length what they lack in height; their backs are long, thin, and solid with muscle and they use them somewhat as constrictor snakes do, wrapping themselves around a catch to hold it down. Fortunately, weasels do not have to sacrifice muscular strength for size. Going down the range of body sizes from larger to smaller species, weight decreases faster than strength. No lion can run with a carcass of even half its own weight, but a weasel can bound off with a rabbit twice as heavy as itself, which would be as if a terrier were to carry off a sheep. Associated with this seemingly disproportionate strength is the self-confidence and pugnacity for which weasels are famous. Most larger animals, even trained hunting dogs, faced with a spitting, shrieking bundle of teeth and claws will, quite rightly, choose to go home.

The immediate ancestors of the weasels appeared toward the end of the Tertiary period, when the newly evolved grasses were replacing forests over vast areas of the North Temperate Zone. These grassy expanses were becoming populated with

the early kinds of voles and lemmings, which offered a huge new food supply to any predator that could catch them. Although the thick grass was an effective curtain that protected the small rodents from most raptors and larger carnivores, the early weasels could easily track them along their runways and tunnels among the matted roots. At that time, apparently, rodents were abundant and other small carnivores few; I have suggested that the weasels took the opportunity to become specialists at tunnel hunting. Better still, they soon discovered that they never had to go to the trouble of building their own dens, since a rodent's grassy nest makes an ideal, ready-made residence. Weasels habitually inspect all likely looking nests, and if the owner is at home, it is likely to be asked to stay for dinner. In cold weather, weasels improve the nest's insulation by lining it with fur from kills.

When glacial climates began to grip the northern regions with frigid winds and paralyzing frosts, the weasels were already equipped to make the most of these new conditions. They could continue to hunt rodents and to raise litters of their own in fur-lined grass nurseries, snug under the insulating blanket of snow. During interglacial periods, such as the present one, the weasels' habitat thawed out and became repopulated with warmer-weather prey, such as cottontail rabbits and water birds. Along with them came larger predators, but weasels, ever the opportunists, continued to hunt whatever they could catch while trying to keep out of harm's way themselves.

When set upon by a fox or cat, a weasel (like its cousins, the skunks) can unleash its "stink bomb"—a powerful discharge from musk glands under the tail—but that would not deflect the intentions of a





A short-tailed weasel peers out of a stone wall, left, a favorite habitat. Such walls provide cover, shelter, corridors between hunting areas, and handy, rodent-infested larders.

Below: When pursuing its prey in the snow, the weasel is itself hunted by owls and hawks, despite its white camouflage. Raptors are sometimes fooled into a misdirected strike by the weasel's black tail tip.

Wayne Lankinen



obvious feature on which the raptor can focus is that bobbing black tail tip.

Powell's experiments with red-tailed hawks and dummy white weasels showed that the hawk usually dived for the black tip, but the thin tail slipped out of its grasp. Only when the experimental dummy had a black spot in the middle of its body could the hawk catch it nearly every time. However, the smallest weasels lack the black tips, probably because their tails are too short to hold the black tip far enough from the body, out of talon's reach.

Still, hawks and owls do catch weasels occasionally, and in some years they seem to catch a lot of them, according to some studies of the least weasel. Is it possible that they catch enough to make a real impact on weasel numbers? I think not, because the normal annual mortality rate of least weasels is about 75 to 85 percent a year anyway. When voles, the least weasels' primary prey, are declining, most of the weasels will starve to death; their chances of encountering a famine are much higher than their chances of being caught by a raptor.

Small size carries other, less obvious dangers for weasels, especially in the colder parts of their ranges. The weasel

way of life is normally conducted in the fast lane; almost everything a weasel does, from a routine cruise around its territory to a concentrated search for a meal or a mate, is done in high gear. A weasel's normal pulse and respiration rate sound frenetic by human standards. I once put my ear to the chest of an anesthetized weasel to try to count the heartbeats, but it proved impossible: the heart was purring like a little sewing machine. Russian physiologists have measured the pulses of resting stoats at about 400 to 500 beats per minute. An enormous amount of food is needed to fuel a weasel's activities and to keep it warm, which means that weasels have huge appetites. They are also particularly sensitive to cold weather because their long, thin bodies have a relatively large surface area from which heat escapes. Unlike many chunkier small mammals, they cannot curl up into a ball to retain heat when asleep; nor can they insulate themselves with thick fur or fat, which would prevent them from entering rodent tunnels. Other animals can escape cold weather by hibernating, but not weasels. Because of their racing metabolism, weasels must eat frequently or die. Thus, the failure to find enough prey for the day is a real and constant danger for all wea-

fast-diving hawk with little sense of smell. Weasels therefore usually avoid bare ground and patrol under the hedges around a field rather than venture out under open sky. In winter, however, life is decidedly riskier for a weasel. Cover is sparse, and too many maneuvers for safety's sake may cut into precious hunting time. Under these conditions, a weasel will sometimes opt for the chance that a raptor will miss its strike.

A series of elegant experiments published in 1982 by zoologist Roger Powell, then at the University of Chicago, demonstrated how the black tail tips of the two larger weasel species function to deflect predators. Both the long-tailed and the short-tailed weasels change to white winter coats in the northern parts of their range. A white weasel racing across a snowy field, although camouflaged, is still visible to a sharp-eyed hawk, but the most

A short-tailed weasel moves easily through the narrow tunnel of a dead log, below. This studio photograph illustrates the tunnel-hunting adaptation of the species. At right, a female short-tailed weasel bounds through the grass, moving one of her youngsters to a new hiding place.

Dwight R. Kuhn



sels (see "Stop-and-Go Stoats," by Mikael Sandell, *Natural History*, June 1988).

The only time when life is relatively easy for weasels is when there is a population explosion of small rodents. In northern lands this happens about every three to four years. Few individual weasels live that long, so the odds are much less than fifty-fifty that any given individual will meet a good year during its lifetime. Reproduction is a huge extra cost added to an already expensive life style, so female weasels need a steady supply of prey in order to breed successfully. They breed in most years, but if prey is short, few of their young survive to independence. During a rodent peak year, however, males can fertilize many mates, females can rear large litters, and many of the young survive. In such years, weasels seize the opportunity to produce as many offspring as possible. The breeding cycles of the larger and smaller weasels are very different, but the result is the same. Either way, their trump card is their small size compared with other carnivores.

Of course, being small is a relative matter. Within the weasels as a group, local races vary enormously in average body measurements, and there is even more variation between individuals. The three

Northern Hemisphere species grade in size from large (*Mustela frenata*) through medium (*M. erminea*) to small (*M. nivalis*). Within each species the males are always larger than the females, and both the males and the females of all three species vary in body size across the map. These variations suggest that the point of balance between the risks and rewards of being small is not constant but depends on local conditions.

The differences in size between the larger and smaller weasels are associated with slight differences in their diets. The smaller weasels concentrate almost exclusively on small rodents, songbirds, and even insects, while the larger weasels take these plus rabbits, squirrels, and gamebirds. The smaller and larger weasels probably cannot avoid competing for the same prey, especially for small rodents, the favorite fare of all weasels. When there is a plentiful supply of different-sized prey, competition does not matter because weasels of any size can still get enough; but when one kind of prey becomes scarce, the result can be very different for larger and smaller weasels, depending on which size of prey is gone. For the larger weasels, a shortage of rabbits is a disaster that the smaller weasels may

hardly notice; conversely, a shortage of voles decimates the smaller weasels, while the larger ones get by on other prey.

Two large-scale, unplanned field experiments involving the two British species of weasels illustrate the point. During the 1880s, hundreds of stoats and of the much smaller common weasel were transported from Britain to New Zealand, in the hope that they would help control the imported European rabbits, which were overrunning crops and pastures. The stoats thrived on the rabbits, but since New Zealand has no voles, the common weasels became (and remain) scarce. Conversely, when the myxomatosis rabbit virus invaded Britain in 1953 and wiped out 99 percent of the rabbits, stoats practically disappeared, while common weasels became much more abundant. Both species are constantly vulnerable to the risk of radical changes in prey resources; which



of the two gets the benefit is decided by the turn of the wheel, over which, like human gamblers, neither has any control.

Among the larger kinds of weasels living in temperate climates, the same contrasts can be observed between the two sexes, even though they live together and hunt the same prey. Females concentrate on small rodents, especially while rearing young (infant weasels literally cut their teeth on rodents), while the males regularly take rabbits as well. For the smaller weasels, such as those northern populations that live for much of the year under snow, rabbits are not an option; even the males generally have to stick to rodents.

Although all weasels are fierce and bold hunters, they must also avoid danger as far as possible, so it makes sense for smaller weasels to specialize on smaller prey. And, equally clearly, the weasel body plan works well in a great range of sizes. The

interesting question is, does natural selection adapt the body sizes of weasels to the size of the prey available or does it adapt their diet to the size they are?

After studying the diets of European stoats, zoologist Sam Erlinge concluded that regional variation in the size of stoats is directly related to the size of the prey available. In the northern parts of their range, such as Scandinavia, stoats are relatively small and go for smaller prey on average than do the larger, southern varieties, such as those found in France. Is that a general rule? If it is, it should be possible to predict the average size of stoats of European stock living on prey resources different from those in Europe.

The transplanted stoats of New Zealand are an interesting test case because the prey available to them is on average much larger than that hunted by their European brethren. Very small mammals

are scarce (no voles and only introduced house mice), while larger ones are relatively common (roof rats, Norway rats, rabbits, hares, and Australian brush-tailed possums). If prey size dictates weasel size, then New Zealand stoats should be larger than those in Europe.

In fact, the stoats are becoming larger, even though they have lived in New Zealand for only about a century. There is also substantial local variation in size within New Zealand, and that, too, seems to be related to the local prey size. But we still do not know whether the slight increase in the average size of New Zealand stoats is genetic or whether the near-universal relationship between body size and diet in stoats is causal or consequential.

An alternative suggestion is that because weasels are so vulnerable to the cold, the size that best balances the risks and rewards of being small might be influ-

Having just captured a long-tailed weasel, a great horned owl prepares to feast atop its perch.

Alan and Sandy Carey



enced by the local climate or, at least, by energy equations in which ambient temperature is a crucial variable. In the brutal winters of the far north, all weasels have to be small enough to live and hunt under the snow, but in warmer climates (including most of New Zealand) there is less need to avoid exposure to the cold and more larger prey to hunt, so larger size is favored. The largest weasels in Europe are found in France, Italy, and Britain; in New Zealand, nearer the equator than Britain, one of the two British species has become larger still. But the whole answer to the riddle is still unknown.

Body size is one of the most important facts of life for any mammal; it determines what the animal can eat, where it can sleep, which are its enemies, and how much it costs to keep warm. The best size to be, determined by the sum of all these considerations, need not be the same at all times and places. Individual animals have to take a chance on getting the equations right for the time and place in which they live. Weasels are among the animals that most vividly illustrate these complicated calculations and the costs of getting them wrong. Long may they continue to work on their sums and puzzle us with their answers. □



In Vermont, a female short-tailed weasel in summer coat tears into a ruffed grouse she has killed. Although large birds are not their usual prey, weasels may take the risk of attacking them if the opportunity arises.

Ted Levin





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*Major Mitchell cockatoos share a perch
in a eucalypt tree in Western Australia.
Close physical contact and mutual
preening are typical of mated pairs.*

Graeme Chapman



A Confusion of Cockatoos

Changing habitats make strange bred-fellows

by Ian Rowley



We are lucky in Western Australia—although some farmers may think differently—in that six species of cockatoos commonly roam the region's wheat fields. Often three or four different species, in separate flocks of more than 100 birds each, can be seen foraging on the same crop stubble. Starting in the 1970s, I spent several years studying the galah, or rose-breasted cockatoo, which immigrated to the wheat belt from drier inland areas and became an agricultural pest. Then I went on to study less abundant cockatoos native to the area and named after the early explorer Major Mitchell, who, like me, was intrigued by these colorful extroverts.

My study area near Yandegin, at the northeastern boundary of the wheat belt, encompassed about 170 square miles. To recognize individual birds, my colleagues and I needed to catch and mark the cockatoos. Ornithologists usually accomplish this by attaching colored bands to their subjects' legs, but because these parrots have particularly short legs that are hidden most of the time by body feathers, we equipped them instead with wing tags—colored aluminum circles bearing a contrasting pair of engraved numbers or letters. We fastened these on the wings carefully so as not to hurt the birds and so that we could easily read the combination of letters or numbers from 100 yards away.

Once we had recognizable individuals, we found their nests, observed their courtship and mating, and then monitored the progress of their nesting attempts. When the second generation was old enough, we placed wing tags on them and followed the entire family when it left the nest hollow and joined others foraging in large flocks on the harvested wheat fields.

After studying the Major Mitchells—also known as pink or Leadbeater's cockatoos—for a year or two, my colleagues and I were puzzled by repeated sightings of one or two galahs feeding with the Majors. Even though other galahs were available for them to associate with—thousands were feeding in flocks nearby—these galahs moved over the paddocks with the Major Mitchells as they searched for food within a few yards of them.

Other strange associations gradually

A flock of immature Major Mitchells resting in a eucalypt, below, includes a single cross-fostered galah (middle right). Galahs, right, forage on wheat stubble in winter. Flocks tend to be larger in winter than in summer, when food is abundant.

Graeme Chapman



became apparent. After one nesting season, in two of our fifteen tagged pairs of Major Mitchells, the female died, and much to our surprise, each of the surviving males was seen to be keeping company with a female galah throughout the next winter. The galahs involved, although normal in plumage and general appearance, sometimes called like Major Mitchells and even flew like them.

The next season, two perfectly normal pairs of Major Mitchells raised clutches that each contained three Major Mitchell nestlings and one galah nestling. We first thought that the odd chicks were hybrids. But no: as the young galahs grew up they showed no signs of being anything other than true galahs, except that they seemed to think that they were Major Mitchells.

After several years of watching, we were able to piece together a likely scenario to account for the galahs' confused and confusing behavior. The history of the land itself offered a clue. Until about 1900, the vast area that is now known as the wheat belt of Western Australia was largely a heathland with occasional patches of tall eucalypts. Such habitat

was not at all to the liking of short-legged, strong-flying galahs, which thrived in the more open shrublands of the semiarid country farther inland, feeding on seeds they usually gathered from the ground.

The land that was to become the wheat belt was the natural home of Major Mitchells, larger birds with strong bills that enabled them to cope with a wide variety of seeds and nuts produced by the native vegetation. Early in this century, wheat farming spread rapidly. As fertilizers, railways, and big tractors became available, the heathland was easily cleared. The resultant farmland appealed to galahs, which moved in and prospered. While not colonial nesters, galahs are sociable birds and readily tolerate other pairs nesting within thirty feet, so the scattered patches of woodland left among the wheat fields easily supported the expanding galah population.

Major Mitchells are by no means so tolerant of their own kind during the breeding season. I have never found two pairs nesting closer than a mile apart. Each residual patch of woodland, therefore, can hold only one pair of Majors.



This conspicuous spacing, and the birds' popularity as pets, led to the plunder of their nests for the pet trade. The law now forbids the harvesting of wild nestlings, but for many pairs of Majors, the law came too late. They shrank back to the outer edge of the wheat belt where they could still find plenty of trees and plenty of other pairs so that once nesting had been completed, the local population could form feeding flocks of more than 100 individuals. These flocks are vital social arenas where young Major Mitchells grow up, meet their future mates, and find a replacement should their otherwise life-long mate die. Our study area supported a flock of 100 to 150 Majors, which, in turn, served as an integral part of the social milieu for some twenty nesting pairs.

Today, the search for more wheatland



continues, and timbered areas become scarcer every year. Replacement trees are few, and most seedlings are eaten or trampled by rabbits and sheep. Competition for old hollow trees in which to nest becomes more and more severe, and the Majors retreat farther. This, then, was the background to the scenes that we were witnessing at Yandegin. Following the clearing of native vegetation, two species of cockatoo had been brought into intense competition for the increasingly scarce tree hollows.

Both galahs and Major Mitchells are spring breeders in southern Australia, but they differ in some aspects of their nesting behavior. Galahs tend to return to their nest hollow every evening and to roost nearby throughout the year, whereas Majors only revisit their nest hollow shortly

before they intend to lay. Although we cannot describe precisely the events that led to galahs behaving as Majors, our observations from 1978 through 1983 suggest the following sequence.

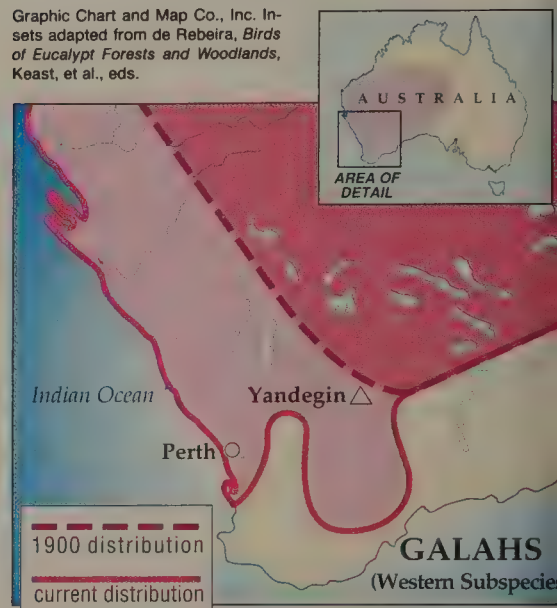
During the austral winter, a pair of galahs, looking for a new nest hollow, find a suitable piece of real estate and begin the lengthy business of settling in. (They are one of the few parrots that line their nests with freshly plucked leaves, and this takes time.) By mid-August, the galahs are nearly ready to lay, when back come the pair of Major Mitchells that have nested in the hollow for years, maybe for generations. Possession may be nine points of the law, but when the contender is 20 percent bigger and has a bill like wire cutters and muscles to match, the battle is apt to be one-sided. The Majors always win.

Galahs lay eggs every other day, completing a four- or five-egg clutch over ten days and starting to incubate only toward the end of that time. The dispute over ownership of the nest hollow goes on for several days, during which time the female galah may lay an egg. Major Mitchells and galahs both lay ovoid white eggs of much the same size, so they look very alike, particularly when five feet down a hollow. Eggs can also be buried in the loose leaves at the edge of the nest bowl and reemerge only later as the brooding bird rearranges the clutch.

Major Mitchells also lay their eggs at two-day intervals, leaving the hollow largely unattended in the interim. We therefore envisaged two pairs, each of a different species of cockatoo, thinking that they owned a particular hollow and,

As vast areas of southwestern Australia were converted from heathland to wheat farms, galahs extended their range by some 54,000 square miles. Major Mitchell cockatoos, native to the region, have retreated northward.

Graphic Chart and Map Co., Inc. Insets adapted from de Rebeira, *Birds of Eucalypt Forests and Woodlands*, Keast, et al., eds.



over the early days of ownership confusion and egg laying, both contributing to a mixed clutch. "War" between the two species may continue for several days until the Majors begin to incubate in earnest, whereupon the galahs simply give up. Both Major parents continue to alternate incubation bouts, little realizing that they may be raising a "changeling."

After three weeks, the first egg hatches and the others follow within a few days of one another. The galah egg has just as good a start as the rightful eggs. I have spent many hours watching the behavior of parent and young cockatoos via a glass-backed nest box in an aviary. The galahs are by far more demanding and noisy as nestlings than are the Major Mitchells. I never watched a mixed brood in competition, but I am quite sure that a Major Mitchell parent faced with a galah chick would never refuse this "superstimulus." And so the young galah grows up with his foster siblings in the dark confines of the nest hollow, fed and cared for by its unwitting Major "parents."

Compared with birds of the same size reared in open, more exposed nests, cockatoo nestlings are in no hurry to leave the safety of the nest hollow. Only after seven weeks of nest life is the galah ready to fledge. This is another factor that contributes to a fosterling's success, for the Majors take approximately a week longer to reach fledging. In practice, this means that the galah fosterling leaves the hollow before its siblings and hangs around the nest tree, ambushing its Major Mitchell foster parents as they arrive to feed the less precocious young Majors still occupying the nest hollow.

I watched at one of these nests for many hours and was fascinated by the complete disregard that a fosterling showed for any passing "real galahs." These adult galahs, irresistibly drawn to the conspicuously helpless fledgling galah waiting to be fed, appeared nonplussed when they were ignored or even rebuffed by the young bird. Although the visiting galahs called and displayed to the fosterling, the young bird remained unmoved. This apparent obliviousness to their own species suggests that fledgling galah chicks have no innate abil-

ity to recognize their own species as such.

From intensive studies, we know that nestling galahs learn to recognize their parents (normal wild galahs) during the last ten days or so of nest life. Not surprisingly, fosterlings learned to recognize the birds providing them with food and to respond to them as parents, even though they were a different species and had different calls. At fledging, fosterlings used distinctly galah vocalizations—the "begging," "being fed," and "distant contact" calls—that must be innate.

Once a fosterling and its Major siblings had fledged, the family remained together for several weeks; the parents caring for all the young by feeding and preening them and keeping alert for predators. To keep the family together, the adults used Major Mitchell contact and alarm calls; to survive, the fosterling had to learn these calls in addition to its innate repertoire of "galahese."

After the young had been out of the nest for some six weeks, they began to feed for themselves, and a crucial difference between the socioecology of galahs and Major Mitchells came into play. Galah families fledge into aggregations that I have

termed "crèches," because they resemble communal nurseries with the young from many nests parked in one patch of woodland while the parents forage. After a week or two the juveniles leave the crèche and accompany their parents to the foraging grounds. In time they form juvenile flocks, which become increasingly mobile, although the young are still tended by parents that may commute as much as eight miles each evening to roost near their nest hollow, thus reinforcing their ownership. The juveniles do not commute but roost near the feeding site. Six or



Galahs drink at a rock hole. Water is at a premium in Western Australia.
Graeme Chapman



seven weeks after the offspring fledge, the galah parents desert them.

Major Mitchell parents behave quite differently; they tend their offspring well into the autumn, moving as a family to join the local flock during the summer. Fosterlings, therefore, received prolonged parental attention from the Major Mitchells and were not exposed to the galah crèches or juvenile flocks where they might have learned to behave like galahs. They grew up learning to call and behave like Major Mitchells.

Perhaps the most striking aspect of this

picture of biological confusion was shown by the way the fosterlings flew. Galahs are very fast, strong fliers, diving and wheeling with what can only be described as obvious enjoyment and great skill. Major Mitchells are much slower and more reluctant to fly long distances. One is like a fighter plane; the other, a transport. The fosterlings instinctively flew as galahs, but in so doing, they sometimes outstripped their foster family and had to circle back and adopt their slower wingbeat rate in order to maintain company.

Most cockatoos do not breed until they are more than two years old, and I have often been tempted to think of immature birds as representing a third sex, for during their first two years they appear to associate equally readily with males or females of their species and to have no hang-ups over sex, territories, or nest hollows. The fosterlings seemed to integrate happily into the apparently sexless environment of the local foraging flock.

Two of our wing-tagged fosterlings (AB and NO) came from nests about three miles apart. So far as we know, they first met each other when they were three months old and their families were feed-

ing in the same area. In the two years that followed, they were frequently seen feeding in the same flock, where, although they appeared to be shunned by most Majors, they made little effort to associate with each other. Only once was AB seen being preened by NO and only once by a Major Mitchell. This suggests generally poor social integration, since both species usually enjoy mutual preening and engage in it frequently.

In addition to learning to fly and to call like Major Mitchells, these fosterlings, as they matured, learned to feed on a wide variety of foods usually ignored by predominantly ground-feeding galahs. I watched one excavate wood-boring larvae in acacias alongside Major Mitchells. I don't know how successful this bird was, but typical galahs have never been seen to attempt this form of feeding.

We followed our two cross-fostered galahs for as long as we could. NO was last seen in 1981, and AB in 1984. We thought that these males might eventually find mates, but although they formed associations with Major Mitchells, neither succeeded in breeding. The three cases of socializing between a known breeding male Major and a galah all involved female galahs; no mating was observed. We cannot be certain of the origin of these particular galahs, but we strongly suspect that they were also products of earlier mixed clutches.

We can now understand how the behavioral barriers that usually prohibit cross-species matings between galahs and Major Mitchells could be overcome. Hybrids could result if a confused fosterling that thinks it is another species—and behaves like that species—breeds with a member of that species. I do not believe that a case of Majors raised by galahs, and growing up thinking they were galahs or taking galah mates, is likely to arise: nestling Majors do not beg as loudly and persistently as galahs and would probably starve in the nest. Nor do such mixed clutches seem viable between other species, for example galahs and corellas, another species of Australian parrot. The fortuitous combination of a shorter nestling period and louder, aggressive begging allows a mis-



Crest raised in alarm, a female Major Mitchell pauses near muddy but potable water.

Graeme Chapman

Three Major Mitchells and a wild galah—Major Mitchell hybrid (second from right) perform a high-wire act, below. In the late 1970s, the hybrid was an integral member of a flock of some thirty Major Mitchells that came once a day to drink fresh water at the Eyre Bird Observatory in Western Australia. An adult galah, right, lands at its nest hole. Tree hollows are dwindling but vital nest sites for both galahs and Major Mitchells.

Graeme Chapman



placed galah egg to hatch and the chick to thrive in the nest of Majors.

The genetic integrity of two species in the wild is often maintained simply because the two live in different habitats and rarely meet. If, however, the two species live side by side, they usually develop "isolating mechanisms," physiological or behavioral traits that make cross-mating difficult or impossible in the wild. Hybrids, therefore, rarely occur and indeed hybrids between two true species are likely to be infertile. But environment is sometimes so altered by humans—as has happened in Western Australia—that two species that have previously been separated come into contact and cross. This can result in a hybrid zone that may persist for years. In most such cases one species ultimately swamps the other or the two species man-

age to evolve such effective isolating mechanisms that crossing becomes rare or ceases altogether. The galahs and Majors brought into contact and competition by the wholesale alteration of large parts of Western Australia, however, seem to be maintaining their genetic integrity despite the confusion of galah fosterlings. Hybridization in the wild between the two species is, so far, a rare event; we heard of only one case in six years.

Our studies of this unusual interplay of species has shed light on one way in which hybridization may arise. An understanding of the processes involved in the field may be helpful to those charged with the management of endangered animals, in which dilution of gene stock through crossbreeding could further undermine a species' chances for survival. □





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The Ape That Was

Asian fossils reveal humanity's giant cousin

by Russell L. Ciochon

For thousands of years, Chinese pharmacists have used fossils—which they call dragon teeth and dragon bones—as ingredients in potions intended to cure ailments ranging from backache to sexual impotence. The fossil-rich caves of southern China have been, and still are, sedulously mined by farmers, who sell these medicinal treasures to apothecaries in the cities. In just such a pharmacy, in Hong Kong in 1935, the German paleoanthropologist Ralph von Koenigswald came across a large fossil primate molar that did not belong to any known species. Over the next four years he searched further in Hong Kong and Guangzhou (Canton) and found three more of the oversize teeth, thereby establishing the existence of an extinct ape, the largest primate ever to roam the earth. He named the genus *Gigantopithecus*, meaning “gigantic ape,” and the species *blacki*, in honor of his late friend and colleague Davidson Black.

At the time of the discovery, during the 1930s, von Koenigswald was working primarily in Java, unearthing fossils of human ancestors and their relatives. China's unique fossil shops had already played a major role in tracking down *Homo erectus*, which lived in Asia between about one million and 300,000 years ago. *Homo erectus* remains were first unearthed in Java in the 1890s, but pursuit of the source of dragon bones subsequently led to a system of fossil-filled crevices and caverns near the town of Zhoukoudian (Choukoutien), thirty miles from Beijing. There, in 1929, a team of Chinese and Western scientists discovered the first of a series of *Homo erectus* skulls that became world famous as “Peking man.”

The original fossils of Peking man disappeared during the confusion of World War II—fortunately, after they were described and cast by anatomist Franz

Weidenreich. The war also caught up with von Koenigswald, who was taken prisoner by the Japanese in Java. His precious collection of *Gigantopithecus* teeth—at that point, the only known specimens of the fossil ape—spent the war years in a milk bottle buried in a friend's backyard on the island.

Meanwhile, however, Weidenreich, who had retreated from Beijing to the American Museum of Natural History in New York, set about studying plaster casts of the four teeth. Because of the unusually large size of a few of the *Homo erectus* specimens from Java, Weidenreich came up with the notion that there had been a period of gigantism in human evolution, and that modern humans were the diminutive descendants of these giants. In *Apes, Giants, and Man*, published in 1946, he argued that the *Gigantopithecus* teeth were humanlike, and that von Koenigswald had been mistaken in considering the animal an ape rather than a member of the human family tree.

During von Koenigswald's wartime internment, Weidenreich's views became widely accepted. To end the controversy that arose, more complete specimens of *Gigantopithecus* had to be found, a task only the Chinese could undertake, for the country was closed to Western scientists. In the 1950s, with the establishment in Beijing of what is now the Institute of Vertebrate Paleontology and Paleoanthropology, Chinese paleontologists began to search for the source of the *Gigantopithecus* fossils. Two veterans of the Peking man expedition, Pei Wenzhong and Jia Lanpo, headed a team that visited the warehouses that supplied all the apothecary shops in China with dragon bones and dragon teeth. They found vast quantities of fossils in Nanning, the capital of Guangxi Province. From there, they divided into two teams: one, led by Pei,

headed north; the other, led by Jia, went south.

Jia's paleontological detective work took him to southernmost Guangxi, a karstic, or eroded limestone, region of great rock towers riddled with caves. In the town of Daxin, which the local people said was the source of all the fossils, they were directed to an old woman who had, in her house, a bamboo tray full of fossils. One of them was a *Gigantopithecus* tooth. She pointed out a very tall rock tower, described by Jia as “a hundred meters straight up—almost falling over, it was so steep.” The mouth of a cave was clearly visible behind a screen of brush.

Although it was four in the afternoon and raining hard when they arrived, Jia says, “We were young, and couldn't be restrained. We climbed straight up to that cave.” That very day, Jia himself found a *Gigantopithecus* tooth embedded in a hard, reddish matrix, the first time that a paleontologist had discovered a fossil of *Gigantopithecus* in a geological context.

Meanwhile, Pei was making a more momentous discovery to the north. Word had reached the scientists of a giant jawbone discovered by an old farmer in 1956 at a cave site called Liucheng. When Pei saw the fossil, he was able to identify it at once as the jawbone of *Gigantopithecus*, because it had all but three of its teeth still attached. On a second visit, in 1957, Pei's team discovered the first *Gigantopithecus* jawbone in place, in a very hard deposit resembling red clay. Another was excavated in 1958. One of the jawbones was extraordinarily large; presumably, it belonged to an adult male, while the other two were thought to be from an adult female and a juvenile.

In addition to the jawbones, Pei's group discovered nearly a thousand *Gigantopithecus* teeth and numerous other mammalian specimens, including some unusual



dwarf varieties. Among them was a short-muzzled panda half the size of the living giant panda. Chinese scientists have recently suggested that this dwarf species was a direct ancestor of the modern one.

The next development came in 1965 with the discovery of twelve *Gigantopithecus* teeth at Wuming, a few hours' drive north of Nanning. These teeth were significantly larger than their counterparts from Liucheng, and the other animal fossils found with them suggested that the site was considerably younger (current estimates are that Liucheng is one million years old and that Wuming is between 300,000 and 400,000 years old). This suggested, first, that *Gigantopithecus* was around as a species for a considerable period, and second, that it may have become larger as the species evolved. This is a trend seen in other large mammals that evolved during the Pleistocene epoch, 1.8 million to 12,000 years ago.

A striking confirmation of both points was the discovery three years later that a smaller, earlier form of the giant ape had once inhabited northern India. In 1968, a farmer came forward with three pieces of a jawbone he had found twenty-four years before, when he was a boy of twelve working in his father's field. The specimen was identified by primatologist Elwyn Simons as belonging to a distinct species, *Gigantopithecus giganteus*, about half the size of *Gigantopithecus blacki*. The new species was not only smaller but also more ancient, coming from sediments that have been dated (by paleomagnetic reversals) to about 6.3 million years ago.

The discovery of the jaws resolved, at least for most scientists, any doubts that the creature was apelike and not, as Weidenreich had argued, humanlike. Based on the fossils, *Gigantopithecus* is now placed among the Asian apes, a descendant, along with the orangutan, of the earlier ape ancestor *Sivapithecus*, best known from an 8-million-year-old skull discovered in Pakistan. Its size and ape affiliation suggest *Gigantopithecus* was a ground-dwelling, fist-walking creature.

While more teeth of the extinct ape have been found, no other bones have turned up. Based only on the jaws and



teeth, however, an attempt can be made to reconstruct both the animal and its way of life. The jaws are deep (top to bottom) and very thick. The molars are low-crowned and flat, with very thick enamel caps suitable for heavy grinding. The premolars are broad and flat and resemble molars. The canine teeth are not sharp and pointed but shaped more like what one would expect premolars to look like, while the incisors are small, peglike, and closely packed. The canines and incisors together form a specialized cutting tool, most similar to what is found in some present-day tree sloths and in the extinct giant ground sloth. The features of the teeth, combined with the massive, robust jaws, lead to the inevitable conclusion that the animal was adapted to the consumption of tough, fibrous foods by cutting, crushing, and grinding them.

As a rule, large herbivores subsist on diets of coarse leaves and grasses, which are low in nutritional value but typically available in very large quantities. (Large animals succeed with this regime partly because their metabolic requirements are relatively low, in terms of energy required per unit of body mass.) One suggestion is that *Gigantopithecus*, or at least the larger species in China, was adapted, like the giant panda, to a diet of bamboo, the giant grass abundant in the region. The jaws of *Gigantopithecus* and the giant panda, if set side by side with the jawbones of, say, the gorilla and the grizzly bear, appear thicker, deeper, and more massive. These differences reflect the specialized diet of the panda (and, by inference, of *Gigantopithecus*) compared with the much more general diet of the gorilla and grizzly.

A further similarity between *Giganto-*

Photographed at the American Museum in the 1940s, German paleoanthropologists Ralph von Koenigswald and Franz Weidenreich, below, left and right, pose with the skulls of apes, *Homo erectus*, and modern humans. The first scientist to discover teeth of *Gigantopithecus*, von Koenigswald correctly observed that they belonged to an ape, while Weidenreich argued for their humanlike characteristics.

Photographs courtesy of AMNH



pithecus and the giant panda is a high incidence of tooth cavities. Wu Rukang, in an encyclopedic survey of the *Gigantopithecus* teeth in China, found cavities present in 11 percent of them—an unusually high rate for an ape, but more or less equivalent to the rate of dental cavities in the fossil remains of the giant panda. Another Chinese researcher, Zhang Yinyun, has reported a high incidence of hypoplasia—pitting in the tooth enamel that indicates periods of arrested development. These may be a result of disease or food shortage. While no certain conclusion may be drawn, we do know that bamboo is subject to periodic die-offs, which produce food shortages that threaten the survival of the giant panda.

A more direct line of evidence that could be pursued regarding the diet of *Gigantopithecus* was pointed out to me by

Bob Thompson, a graduate student in New World archeology, who attended one of my lectures about the extinct ape. He suggested we might look at the teeth for adhering phytoliths, microscopic pieces of silica found in many plants. The existence of phytoliths has been known since the early nineteenth century, and scientists had already successfully looked for them on stone tools, to which they apparently bond physically by the combined action of friction and moisture. But it was the first time, as far as I knew, that anyone had suggested looking for them on fossil teeth.

Four teeth were borrowed for study from the British Museum (Natural History) and the Senckenberg Natural History Museum in Frankfurt: an upper incisor, lower canine, lower premolar, and lower molar. After the teeth were cleaned, to insure that what we found was defi-

nately part of the fossils, they were examined under a scanning electron microscope at the University of Iowa by Smithsonian paleoecologist Dolores Piperno. At least thirty phytoliths were found on the teeth, most of them on the molar. We also detected tiny scratches apparently left by phytoliths, which are harder than tooth enamel. In one case, we found a phytolith sitting astride the end of the track it had plowed into the tooth—like a sled stopped in its path in the snow.

More than half of the phytoliths we observed were long and needlelike and could be attributed to the vegetative part of grasses, possibly bamboo. The rest were conical or hat shaped, attributable to the fruits and seeds of dicotyledons. Piperno tentatively identified them as fruits from a tree of the family Moraceae, quite possibly durian or jackfruit, both of which are



A cave near the top of the rounded limestone tower at Liucheng, China, above, has yielded three Gigantopithecus jawbones and nearly a thousand teeth. The largest of the jaws, along with some of the teeth, are compared at right with modern human remains.

Photographs by Kenneth Garrett





At a Chinese pharmacy in Bangkok, the author (center) and archeologist John Olsen (right) search among the medicinal "dragon teeth" for interesting fossils.



common throughout tropical Southeast Asia. This proved that *Gigantopithecus* had a varied diet, although we still suspect that bamboo was its staple food.

What other conclusions can be drawn about the extinct ape? An outstanding characteristic of giant herbivores is their extreme slowness. They have no particular need of speed: their size and thick skins protect them from predators, and of course their feeding habits require no more of them than that they move from place to place as they systematically denude the landscape of vegetation. Furthermore, they are usually stuffed full of bulky food to digest, which tends to produce inertia. *Gigantopithecus* probably followed this pattern.

Finally, the adult males of the giant ape were much larger than the females. Aus-

tralian anatomist Charles Oxnard statistically analyzed 735 teeth of *Gigantopithecus* that were complete enough to be measured accurately. He found that they divided neatly into two size groups of equal number, which he interpreted to represent the males and females in the population. The contrast was greater than that seen in any living primate species, including the gorilla and the orangutan, two species in which the male is substantially bigger than the female. In *Gigantopithecus*, the difference in tooth size between the sexes may represent strong competition among males for mates—a clue to the species' social behavior.

To gain a more complete image of what the giant ape looked like, we sought the help of Bill Munns, who creates highly realistic, life-size models of existing endangered primates—gorillas, orangutans, and the Chinese golden monkey—for zoos and educational institutions. Based on the jaws and teeth, and using the proportions of the skulls of existing great apes, we estimated that the average male *Gigantopithecus* had a skull that measured eighteen inches from the bottom of the jaw to the highest point of the sagittal crest (a male gorilla, for comparison, has a skull ten inches high).

The next step was to project a hypothetical skeleton from the hypothetical skull. For this purpose Munns used as references two of the largest terrestrial primates known: one modern, the gorilla, and one from the fossil record, the extinct giant baboon *Theropithecus oswaldi*. In determining the size of *Gigantopithecus*, we felt it necessary to scale the body back a bit, so as not to be influenced too much by the giant ape's extraordinarily deep and thickened mandible. Nevertheless, given that the average male silverback gorilla is about six feet tall (standing erect) and weighs in at 400 pounds, Munns calculated that the average *Gigantopithecus* male was more than ten feet tall and weighed as much as 1,200 pounds—comparable to a large male polar bear.

One intriguing question is what contact our remote ancestor, *Homo erectus*, may have had with the giant ape. That the two coexisted for some time in the same region is supported by direct evidence. In 1965, Vietnamese paleontologists discovered the remains of both creatures at Tham Khuyen, a cave site in Lang Son Province, near the Chinese border. Chinese excavators followed suit, excavating *Gigantopithecus* and *Homo erectus* side by side in



Hubei Province in 1970 and more recently, in 1987, in Sichuan Province.

Gigantopithecus was native to southern Asia, while *Homo* originated in Africa about 1.6 million years ago and migrated eastward, finally arriving in what is now Southeast Asia about one million years ago. The opportunity to explore this nexus attracted archeologist John Olsen and me to Vietnam. One reason we did not choose to go to China was that all the promising sites had been reserved by Chinese paleoanthropologists, and we doubted we would find a new site in a region that had been so thoroughly mined. In contrast, Vietnam had no history of exploiting fossil-rich caves for dragon bones. And so in January 1989 we found ourselves probing four caves at the base of a karst tower near the hamlet of Lang Trang, about 100 miles southwest of Hanoi, as part of a joint American-Vietnamese expedition.

The caves had seemed promising in our preliminary survey the previous May, and as we began work, even local children brought us fossil mammal teeth (although we tried to discourage them), which they retrieved from an underground stream by squeezing through a crevice in the cave we called Lang Trang I. Meanwhile, we began cutting out blocks of breccia, the sediment typical of caves, which is gradually formed by material washed or otherwise transported into a cave and cemented with limestone dissolved from the cave walls and ceiling.

The fourth day of our dig, Friday the thirteenth, turned out to be a lucky one: within the main deposit I found a lens-shaped vein of dark, sandy sediment that was unusually rich in fossils. The material had probably washed into the cave from the nearby Ma River, which in ancient times meandered right alongside the karst tower. Perhaps a violent monsoon had caused the river to overflow its banks and flood the cave. After the waters receded, the slow process of breccia formation began again, sealing the sandy lens within Lang Trang I.

We immediately set to work cutting out hunks of the sandy deposit, revealing a small chamber that we surmised was the source of all the fossils the children had

been bringing us. Our finds included barking deer, a musk deer the size of a big dog; sambar, a large deer with three-pointed antlers; wild boar; and giant panda. A huge, ridged molar, weighing several pounds and belonging to *Stegodon*, an extinct relative of the elephant, assured us that we were dealing with a Pleistocene site that might also contain *Homo erectus* and *Gigantopithecus*. One softball-sized sample of this deposit was later analyzed at the University of Iowa, revealing that it also contained some small teeth and fragmentary limb bones of a diverse microfauna, including rodents, reptiles, fishes, and riverine sponges. These fossil fragments were about the same size as the coarse sand particles they were mixed with.

Then, on January 18, 1989, Nguyen Van Hao made a key discovery: in the floor of the fourth cave he found a premolar of *Homo*. Since it was an isolated tooth, we found it difficult—impossible, really—to identify the species. Since then, four additional teeth of *Homo* have been recovered from caves I, II, and IV. Subsequently, a boar tooth from cave I has been dated (by a method called electron-spin resonance) to about 480,000 years ago. Given this preliminary date, the specimens should be assigned to *Homo erectus*. The discovery helps fill the gap between Zhoukoudian, in northern China, and Java, more than 3,000 miles to the south.

We now have a fairly complete picture of the Pleistocene environment of Lang Trang. The jungle vegetation would have been more lush, but not startlingly different. The fauna, however, would have been striking, with huge beasts of all kinds dominating the landscape. Carnivores such as the tiger and leopard were much more common then and competed for food with species, such as the Asiatic black bear, that have entirely disappeared from Vietnam. And they all competed with the wolf and the Asiatic wild dog in preying on the dozens of bovid and cervid species (cowlike and deerlike mammals). Also present were the rhinoceros and elephant (both now rare) and the stegodon, as well as the orangutan and tapir, both now extinct in Vietnam. The giant panda, also

Munching on bamboo, a giant panda, opposite page, survives on a diet that may resemble that of *Gigantopithecus*. A photomicrograph, below, shows a silica fragment bonded to a tooth of the fossil ape. Its shape indicates it came from grass, possibly bamboo. Color enhancing isolates the silicified mass of plant cells and, within it, the impression of a single cell.

Dolores Piperno and Russell L. Ciochon



Bill Munns stands next to his model of a *Gigantopithecus* male, a quadrupedal, fist-walking creature that also could have stood erect, as bears do.

Bill Munns

Sipping on a communal drink, below, Tai and Muong villagers in Vietnam welcome the author's team to the site of Lang Trang. Bamboo leaves, right, frame the scientists excavating the cemented deposits in Lang Trang Cave IV.

Photographs by Kenneth Garrett



now vanished, chomped its way through the bamboo stands. Taken in this context, *Gigantopithecus* was no freakish monstrosity, but simply the primate example of a Pleistocene phenomenon.

Primates make up 13 percent of the total fauna in our collection. At least five genera are accounted for: two types of macaque monkey, orangutan, langur monkey, gibbon, and *Homo*. So far we have been disappointed only by the absence of *Gigantopithecus*.

Sometime near the end of the middle Pleistocene, perhaps 200,000 years ago, *Gigantopithecus* became extinct. The animal had flourished for at least six million years, quite a respectable figure, but it went the way of a great many genera of every shape and size. At about the same time, the giant panda disappeared from much of its original territory, notably pen-

insular Southeast Asia, until it now survives only in the cold upland regions of Sichuan Province. The best guess as to what caused the panda's extinction in Southeast Asia is human hunting: even now the animal is hunted for food and for pelts, despite the best efforts of the Chinese government to discourage the practice. Similarly, human hunting may have led to the demise of *Gigantopithecus*.

Environmental change may also have been a contributing factor, just as the bamboo die-off in China in the 1970s nearly wiped out the remaining population of giant pandas, with fewer than a thousand estimated to have survived. Or by eating the tender bamboo shoots and exploiting the plant for other purposes, including toolmaking, humans may have outcompeted the giant ape for this critical resource. The competition from both

humans and the giant panda may have been too much.

Gigantopithecus is gone. Or is it? Following the publicity about our research in Vietnam, I have received several letters from veterans who say that they came face to face with huge, hairy apes in the Southeast Asian jungle when they were posted in Vietnam. And of all the theories advanced to provide a zoological identity for Bigfoot, the Abominable Snowman, and other elusive creatures, perhaps the most popular is that they are none other than *Gigantopithecus*, still alive in relict populations (relict populations of Neanderthal man run a close second). While these contemporary reports are probably false, we can contemplate the time when our remote ancestors did encounter the giant of all apes in the tropical forests of Southeast Asia. □



The *Arizona* Revisited

Divers explore the legacy of Pearl Harbor

by Daniel J. Lenihan

A June day finds us once again diving around the battleship USS *Arizona*, whose sunken remains lie in Pearl Harbor. Larry Nordby surfaces beside me clasping his large plexiglass slate; a piece of mylar taped to it is covered with scribbled notations from his dive. "Navy's here," he announces. I look toward the boat ramp where a small landing craft full of "mudzoos" is tying up to the dock of the memorial building that straddles the wreck. Mudzoos are navy divers assigned to the Mobile Diving and Salvage Unit (MDSU) based at Pearl Harbor. We have a symbiotic relationship with these men, whose primary mission is as far from science and historic preservation as ours is from ship husbandry and underwater construction. Our allegiance instead is to the Submerged Cultural Resources Unit, whose bureaucratic title refers to a group of diving archeologists, artists, and rangers employed by the National Park Service to promote preservation of historic shipwrecks and other underwater archeological sites.

This unit was formed in 1980, when the agency leadership decided to establish a mobile team that could help park managers "maintain responsible stewardship" over such sites. Coincidentally, I had just completed a large project in the Southwest, researching prehistoric sites flooded by reservoirs, and had pulled together in Santa Fe an effective team of park service diving archeologists. Unlikely as it seems, I found myself the first chief of a team of professional research divers based in the arid mountains of New Mexico.

In 1983 we began to survey the *Arizona* and subsequently the one other vessel still lying at the bottom of Pearl Harbor, the *Utah*, a battleship that had been converted for use as a training ship. Over the years we have found that our skills are complementary with those of the Navy. They have boats, heavy equipment, youth, brawn, and large numbers; we know shipwrecks. As older, more experienced divers—the "park rangers," they call us—we have a kind of underwater street savvy that the Navy personnel respect.

No diver who works on these ships is unaffected by them for long, particularly





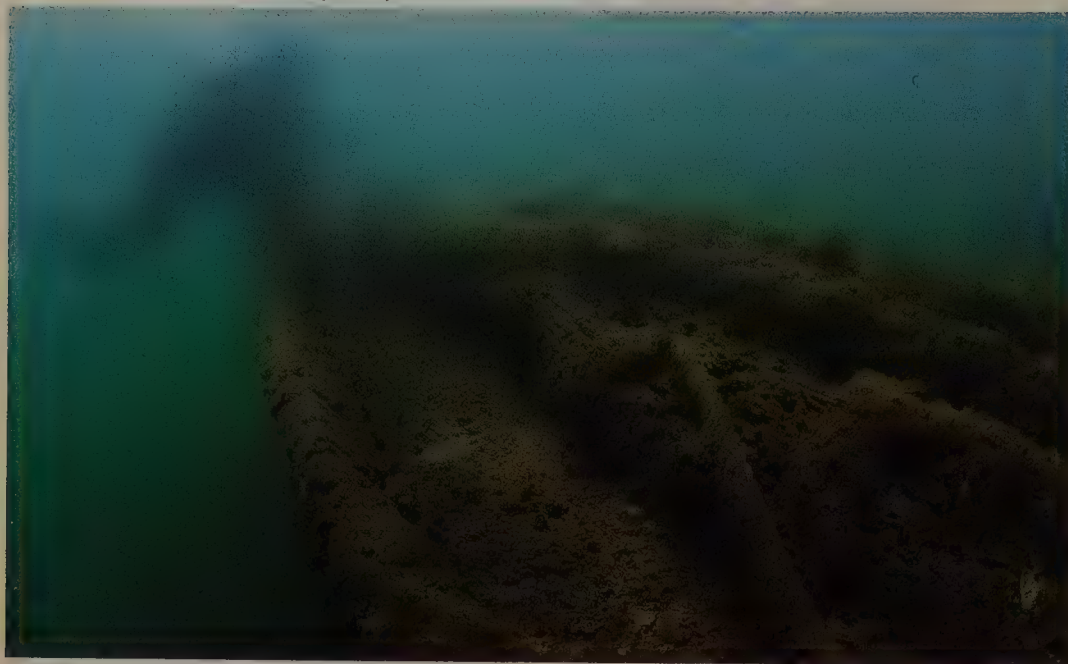
Visitors to the USS Arizona Memorial, below, observe the sunken remains of the battleship. Stripped of much of its superstructure during salvage operations, the hull of the Arizona (drawing) lies partly submerged in silt. The bow, at left, was damaged by the explosion of the forward magazine, probably touched off by a Japanese bomb.

Ed Robinson



A diver, below, examines cables on the Arizona's deck. Amid red sponges, right, feather-duster worms extend their appendages to filter food from the water that washes over the wreck.

Photographs by Ed Robinson



Navy divers. They are aware that there were new faces on the *Arizona* and *Utah* fifty years ago, when the Japanese warplanes caught a major portion of the Pacific Fleet at port. Those men had worn the same uniforms and entertained many of the same hopes and aspirations as their modern counterparts. They are part of the silt now, on the other side of the steel bulkheads.

As we clamber up onto the dock with our equipment, the Navy is raising its dive flags to warn boats that there are divers in the water. A red and white "diver down" flag and a blue and white "alpha" flag (a similar international sign) are soon flapping toward the southwest from the boat dock. From the mast on the memorial, the same colors appear in a more familiar form: Old Glory, the wind keeping her parallel to the others.

On that Sunday morning in 1941, the flags were just being raised on many of the ships when the men standing at attention were distracted by what they took to be some show-off flyboys buzzing the fleet below the altitude permitted by regulations. Even when the first bombs tore into the ships, there was still a sense of there having been some sort of accident. Not until the Rising Suns started to become visible on the planes did the full realization take hold.

Moments before, Flight Commander

Mitsuo Fuchida had led, with what must have been great relief and satisfaction, a complete surprise attack. Many things could have gone wrong; some did. A flotilla of five midget subs had been deployed in the early hours of the morning, and some had been spotted by U. S. patrol planes and ships. The destroyer *Ward* had even attacked and sunk one of those midgets more than an hour and fifteen minutes before the planes made their first strike. Why this incident didn't tip off the Pacific Command to the impending attack is still not clearly understood. There was also the Opana radar station on the north shore of Oahu, which picked up the first wave of attacking planes. When the operators reported to their superiors what their then-developmental radar technology had detected, they were told to disregard the contact because a flight of B-17s was expected from California at that time.

The strange series of events that preserved the element of surprise seemed so unlikely to some historians that they developed a "revisionist" theory of the attack. Advocates of this point of view maintain that President Roosevelt knew the attack was about to take place but let events take their course so that the nation would be outraged and fully united in its response. In any event, Mitsuo Fuchida knew as he glanced down from his rear seat in the cockpit of his command plane



that he had been dealt a winning hand in the most serious of games.

On today's dive I guide Dave McCampbell, MDSU's headman, and Otto Orzech, the commanding officer of a U. S. Naval Reserve detachment, on a swim-over of the site so they can assess the problems their divers must face. Plasticized copies of maps trail from my gloved hand as I lead Dave and Otto on a surface swim toward the bow, where we will begin our dive. I no longer need the maps, but they will help orient my partners. Navy master divers I have previously taken on such tours of the ship have admitted they had not a clue as to their location at any particular point during the dive, although they could help identify certain features unfamiliar to archeologists.

We descend at the "bullnose," near the



very stem, or prow, of the ship. Looking up from a depth of about twenty feet, I notice that the two holes for mooring lines do look like the flaring nostrils of a bull. The *Arizona* is narrow at the bow, and even in poor visibility, one has the sense of looking at the front of a large ship.

Biofouling, marine organisms mixed with products of corrosion, covers the *Arizona* like a thick scab. Archeologists tend to see the substance as "the crud that covers the wreck"; to a biologist, though, it is a rich organic community that reveals much about environmental changes over time in the harbor. The hawsepipes, through which the chains for the four huge anchors used to descend, are heavily carpeted with sponges and other colorful life forms, but they are not so clogged that sunlight can't make its way through the

hawseholes on the deck. Rays of light from the midmorning sun pierce through the gloom from the starboard set of pipes.

Soon we pass a team led by Scott Henderson, a Navy civilian biologist. They are intently collecting a bulk sample of biofouling from the hull; one diver is chipping away with a geologic pick while another holds a makeshift funnel over a canvas bag. Later they will separate the critters in the sample into types and sizes and tabulate their relative numbers. The activity has produced a cloud of silt in the area of major blast damage, where the thick metal plates are ripped and crumpled. One million pounds of explosives in the forward magazine were detonated by a Japanese bomb, blowing out the lower decks and peeling back part of the forward hull; at least, that is our best guess.

There are eyewitness accounts from men who stood on the stern of the *Vestal*, a ship moored outboard of the *Arizona* on the morning of the attack. They swear that a torpedo traveled directly under them and struck the deeper-draft battleship, causing the massive explosion. One survivor visited me in Santa Fe to adamantly make this point after he learned of our conviction that a bomb caused the major damage. These men tell the truth as they saw it, but the material record, the archeology, doesn't confirm what they say. There simply is no torpedo entry hole where they say it should be. Possibly one exists below the silt line, but in that case we would expect to see "washboarding" (a rippled effect) above the silt or some other sign that the hull was compromised; nothing is there. This interplay of words from

A school of surgeonfish, below, swim near the Arizona's bow. Anemones and sponges, right, are part of the colorful biological community that cloaks the ship.

Photographs by Ed Robinson

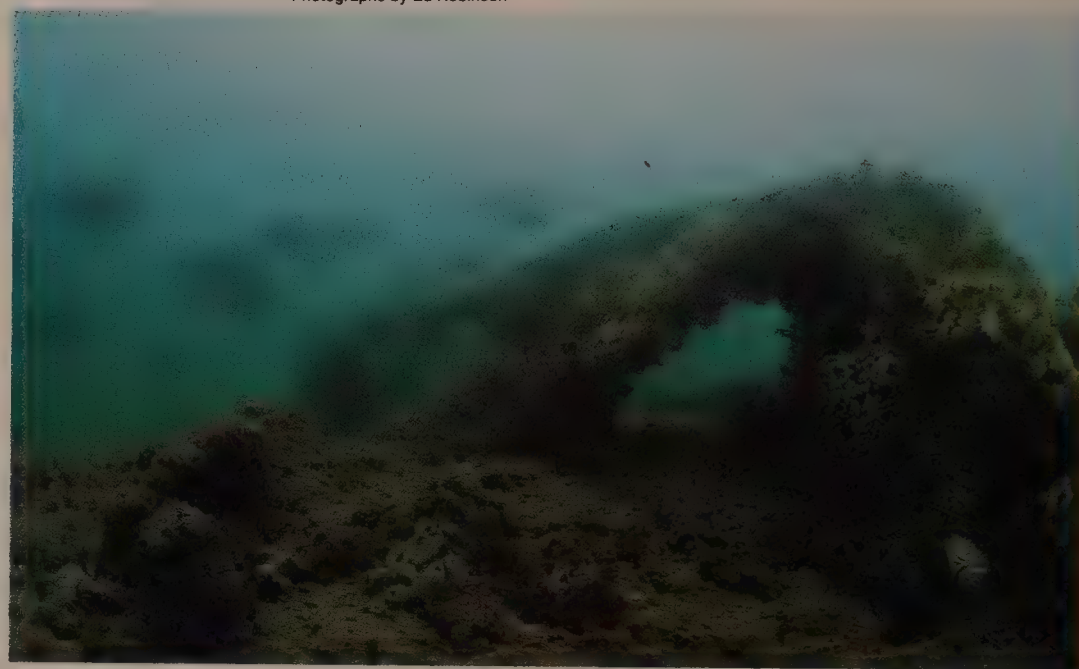
documents, people's memories, and physical evidence of a site constitutes historical archeology, its answers and puzzles.

Grasping the remains of the gunwale with a gloved hand, I propel myself up and over the ship's side and head aft, angling toward the center line of the ship. The cavernous barrels of the fourteen-inch guns in the number one (forward) turret start to take shape in the murk ahead of me. Before the first dives in our 1983 survey, park service and Navy officials in charge of the site thought this turret had been removed along with the others during World War II salvage operations. Other items of interest were found in our first dives, such as live ordnance for the five-inch guns lying right under the busiest part of the memorial.

I see the dim shape of the fourteen-inch guns because I expect them, but my Navy guests concentrate on watching me to keep from becoming separated—we are now swimming in a featureless void between the blast damage and the turret. I distract them with a few hand signals so they will not look up until they are close enough to get the full visual impact. By the time they look ahead to monitor their slow forward progress, the guns are staring them straight in the face. The effect on them is electric.

They have gone from a prone swimming position to bolt upright, their lights now shining at the gun muzzles, which seem incongruously large in the cloudy water. These encrusted steel tubes were once capable of heaving a 1,500-pound projectile about twenty miles. Only battleships had guns like these, and although their importance in naval warfare was soon to be overshadowed by the aircraft carriers, they were still the pride of the world's navies in 1941.

The knowledge that the majority of the battleships in the Pacific Fleet "slept with the fishes" after only a few hours of fighting, with more than 2,400 Navy and other military and civilian personnel killed, had a galvanizing effect on the American public. That the Pearl Harbor attack was flawed, because it probably emphasized the wrong targets and was terminated too quickly, is easier to understand from a



historical perspective. But in 1941, after news of the full damage leaked out—nineteen ships sunk or put out of action—the attack seemed devastating.

I shine my light down the barrel of the gun farthest to the right from our perspective, actually the port gun, and spy my friend the puffer. What was once the most inhospitable environment in the world for any living thing is now a deluxe condo. We swim over the muzzles and head toward the "breeches," the place in the turret from which the gun tubes emerge.

We descend over the turret onto the port side of the ship and stare into an open hatchway with an awning frame still in place. Because we consider the *Arizona* a tomb, we do not enter these interior spaces out of respect, but there is always a morbid urge to push through and see the remains of the carnage only a few feet below us. Of the 1,177 crewmen who died in the attack, the bodies of only a few hundred were retrieved. (The *Utah* is also a tomb, containing fifty-three of the fifty-eight crewmen who were aboard.)

Nearby, the teak decking is exposed where certain species of fish have cleared an area in the silt in which they may deposit their eggs. Wood rarely lasts in a warm saltwater environment like this because of the insatiable appetites of tere-dos, or marine boring worms, but the harbor silt has helped preserve the wood by

creating an anaerobic environment. The fish are inadvertent vandals.

As we pass over the middle of the ship, just in front of the memorial, a crowd of spectators watches over the rail. We enter the remains of the ship's galley, where there are coffee cups and forks used by the crew in 1941, intermingled with the modern detritus from millions of visitors who have been to the memorial over the years: camera lenses, sunglasses, and hair-brushes accidentally dropped and hundreds of coins purposely thrown on the ship, despite the park service request that this not be done. For years, the memorial staff has removed these coins from the vessel, mainly because they can corrode the metal they are resting on, accelerating deterioration. The site managers tell amusing stories about their attempts to get the U. S. Treasury to accept the bags of thousands of semicorroded coins.

When we began our dives, I was puzzled over something else we occasionally found amid these other offerings and lost items: photographs, often of young kids or the very old. I believe now that I know the reason they are here: they are mementos from the living to the dead. These are the photographs of the siblings, children, and grandchildren of the men who lie here, a way of sharing the joys and sorrows of their unknown offspring. An image flashes through my mind of the black



The puffer is a common fish inhabiting the wreck.

Ed Robinson



stone wall in Washington, D.C., on which more than 50,000 names are inscribed. Men and women wearing the park service uniform stand silently by each day as flowers and photographs accumulate at that stark memorial to sons of the generation entombed in the *Arizona*. I wonder how many of the men on this ship never saw their sons, who, in turn, never saw... We move on.

In many places on the *Arizona* the port-holes remain intact. When cleared of a carpet of sponges and other organisms, the glass reveals blackout covers tightly closed from the inside—evidence of the state of readiness the ships were supposed to observe as the clouds of war gathered to the west. In a few places, air remains in the spaces between the glass and the cover, air dating from 1941.

Aft of the memorial, the barbette for the number three turret emerges from the water, the largest single visible feature at the wreck site. Like a huge, cylindrical well casing, the barbette was the support structure for one of the turrets holding a triple set of fourteen-inch guns. As we swim out from the shadow of the memorial and approach the barbette, we run into another of our research teams, taking measurements of electric conductivity potential at selected points on the hull. They are using a device called a bathycorrometer, an instrument shaped like a garage-variety electric drill, which gives a digital readout when pressed against bare metal. By graphing these numbers in the laboratory, we can estimate the likelihood of corrosion at various points on the hull.

Immediately behind this group is another team of three, working with measuring tapes and slates under Larry Nordby's

direction. There is momentary confusion over the unexpected traffic jam in the turbid water, but within a minute the groups have sorted themselves out and continue on their respective missions.

I hold my twosome still until the water stirred up by the passage of so many fins begins to clear. We continue to a point on the deck next to the barbette, where they will see a unique sight. I point to a small globule of shiny black material moving out from the edging of a hatchway on the deck. It spins slowly, like a lazy liquid marble, as it rises gently to the surface. Dave is mesmerized by these oil droplets as they move past his face mask. He pokes one with his finger; it merely breaks into two droplets, but both now spin more erratically as they continue upward.

Years after it sank to the harbor bottom, the *Arizona*'s fuel bunkers are still leaking. When the droplets hit the air a few feet above us, they lose form, becoming part of a slick that bobs on the waves under the gaze of the onlookers standing in the memorial. The slick seems disproportionately large compared with the black drops that created it. There is a sense that the *Arizona*, which is easy to anthropomorphize anyway, is still bleeding slightly from one of its wounds.

Moving aft, I pass by the slightly submerged number four barbette, also stripped of its rotating turret. Entering the barbette from the shallow waters covering the deck is comparable to diving into a thirty-foot-deep well. I take people here only if we are on a specific working mission. This is where the funeral urns of recently deceased survivors of the original attack are laid to rest by Navy divers in modern-day ceremonies; it is the one place

where human remains may be subject to inadvertent disturbance by our activities.

On Oahu in December 1941, death came not like a thief in the night but like an eagle screaming from the sky. The Japanese American press in Honolulu had, in fact, earlier characterized Japanese fliers as "our angry young eagles" when they achieved victories in Java and China. Partly in reaction to such apparent signs of ambiguous allegiance, many Japanese Americans who were loyal to the United States from the beginning of World War II suffered the indignities of internment and persecution. The attackers themselves saw the war in racial terms. Reaction to real and perceived racial slights by Americans regarding immigration quotas fueled the war fever in Japan and contributed to the sense of destiny and self-sacrifice that made the Japanese formidable soldiers, and sometimes cruel and dehumanizing in their treatment of enemies.

Reaching the stern of the ship, I show Dave and Otto the hole where the base of the crane used for hauling aboard the reconnaissance planes had been. Even battleships were serving as mini-aircraft carriers in those days; the seaplane spotters mounted on catapults were a curious addition to the sleek profile of the huge warships. As the advantage of air reconnaissance became more prized during those years of rapidly evolving military tactics, even some submarines were equipped with a watertight hangar for an airplane.

Dave runs his finger over the scalloped metal edges of the hole; neither he nor Otto, experienced salvage officers, need an archeologist to tell them this is the work of cutting torches and not the ragged tears associated with blast damage. Their predecessors in the Navy and civilian sal-



Former memorial superintendent Gary Cummins inspects a fourteen-inch gun.

Larry Murphy; National Park Service

For over two hundred years, the Kwakiutl Indians of Vancouver Island have continued the tradition of the potlatch.

POTLATCHES, elaborate and flamboyant celebrations which commemorate significant events in the life of a family, are occasions of opulent hospitality and luscious cuisine. They are also reinforcements of the host family's status. Spectacular works of art, including stunning masks and lavishly decorated dishes and bowls used for feasting as well as expensive gifts for distribution to guests, are created for these affairs as displays of wealth.

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vage community accomplished a feat after the bombing of Pearl Harbor almost as dramatic, and easily as portentous, as the attack itself. Within several frenzied months, they raised and sent back into action the majority of ships considered total losses on December 7.

Among the fatal flaws of the Pearl Harbor attack, besides missing the aircraft carriers (which were at sea) and the aviation fuel depots, was neglecting the ship repair facilities in favor of the more immediate gratification of seeing battleships in flames. Hardly six months passed before the reconstituted Pacific Fleet delivered a blow at Midway that eliminated any serious chance that the Japanese Imperial Navy would launch another major offensive. Most of the Japanese aircraft carriers and their crews, the backbone of the attack on Pearl Harbor, took their turn on the seabed in 14,000 feet of water, far beyond any hope of salvage.

We are now at the fantail, the very stern, where the *Arizona* narrows markedly and again becomes identifiable as a ship, even in the low visibility. The flag-staff hole is empty now, as the flag—

spattered with oil, water, and blood—was removed by two *Arizona* survivors in the aftermath of the attack. The orange buoy bobbing on the surface here is only a few feet from our heads.

I let the regulator fall from my mouth and breathe in the fresh air as the waters part around me. There is the odor of fuel oil mixed with sea salt and, as I run my fingers over the mask strap on the back of my head, a slightly viscous feeling to my hair. The long, translucent rainbow of oil trails toward the entrance of Pearl Harbor, pushed gently by the prevailing northeasterly winds.

I part company with Dave and Otto and swim on the surface back under the memorial to a place where the twisted steel is only a few feet underwater. This is my favorite place to take a break during working dives on the *Arizona*. Standing on the tips of my fins in chest-deep water and leaning against the jagged remains of a bulkhead that used to be part of the ship's galley, I can hear voices in the memorial through the slap of the waves. There are times when I feel that the voices from below may be louder than the ones from

above. I can imagine 1,177 young men joking, flexing their muscles, feeling immortal at 8:00 A.M. on a sunny Hawaiian morning. Ten minutes later they would be consumed in an inferno, transformed instantly into the stuff of history.

The latest visitors have trailed in from the tour boat and are orienting themselves to the spectacle of rusted metal that stretches below them. From my vantage point in the shadow of the white, arching memorial, I can observe them as they stroll along a promenade over my head, but I myself am visible from only a few points of the walkway. A child looking through the railing at knee height spies me and tries to convince his mother that a man's head is sticking out of the tangle of wreckage in the water beneath them. She knows better and, never glancing in my direction, explains me away as she has other figments of her son's overactive imagination.

Yellow and purple leis have been tossed onto the ship by a group of Japanese. The flowers float by me, carried in the current, their brilliant colors only slightly subdued by the effects of the oily water. □



A fork lies amid debris in the ship's galley.

Larry Murphy; National Park Service

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Land of the Eagle

A VIEWERS' GUIDE

Sunday, Nov. 24–Wednesday, Nov. 27, 1991; 8 P.M.–10 P.M. (ET) on PBS

Thanksgiving Day, Nov. 28, 1991; 10 A.M.–6 P.M. (ET) on PBS

(Check local listings)



B. Reithman

LAND OF THE EAGLE is an eight-part television series that celebrates the magnificent natural history of North America. A unique part of the series' story involves the encounter between Native Americans, who sought to live in harmony with the land, and early European settlers, who sought to tame it and exploit its riches.

Hosted and narrated by George Page,

LAND OF THE EAGLE provides a rich look at the wildlife of this continent from East to West, beginning at Chesapeake Bay and the Appalachians, then to the great forests of Canada, south to Florida's rich wetlands, across the Great Plains, into the majestic Rockies, down to the desert Southwest, north to Alaska, and finally to the golden coast of California.

PROGRAM ONE

The Great Encounter

Sunday, November 24 at 8 P.M. and Thursday, November 28 (Thanksgiving Day) at 10 A.M. (ET; check local listings) on PBS.

Before Columbus' first expedition, the native people who inhabited North America had been successfully hunting and farming across the continent, living with deep respect for wildlife. As *The Great Encounter* illustrates, however, the Europeans who first settled here thought differently. Their eyes held visions of unlimited profit and long-term prosperity from the wealth of natural resources available in this, the "new world."

PROGRAM TWO***Confronting the Wilderness***

Sunday, November 24 at 9 P.M. and Thursday, November 28 (Thanksgiving Day) at 11 A.M. (ET; check local listings) on PBS.

French traders, venturing north in search of a trade route to the Orient, found the St. Lawrence River instead — and more opportunities for profit. Lustrous pelts of beaver provided more than enough inspiration for ambitious traders, but European-induced smallpox decimated their Native American partners and time brought confrontation with British rivals.

PROGRAM THREE***Conquering the Swamps***

Monday, November 25 at 8 P.M. and Thursday, November 28 (Thanksgiving Day) at 12 noon (ET; check local listings) on PBS.

Conquering the Swamps moves south, to Florida, where wild rumors of "El Dorado" — The City of Gold — enticed Spanish conquistadors to investigate. They found mangrove forests, magnificent birds like the great egret and pelican, and "el ligators," (alligators). The program captures these formidable reptiles tenderly caring for their babies.

PROGRAM FOUR***Across the Sea of Grass***

Monday, November 25 at 9 P.M. and Thursday, November 28 (Thanksgiving Day) at 1 P.M. (ET; check local listings) on PBS.

Across the Sea of Grass moves into the heart of the continent. Explorers Meriwether Lewis and William Clark were awed by the endless horizon of the prairie. There they found prairie dogs, grizzly bear, and buffalo, all living on the treeless hills and plains.

PROGRAM FIVE***Into the Shining Mountains***

Tuesday, November 26 at 8 P.M. and Thursday, November 28 (Thanksgiving Day) at 2 P.M. (ET; check local listings) on PBS.

The taming of North America moved further westward. As they pushed on, pioneers met an awesome sight — the Rocky Mountains — a huge obstacle to westward expansion. *Into the Shining Mountains* examines the Rockies' rich and varied terrain, from golden meadows to the frozen peaks. For native peoples here, these mountains were places of powerful spirits.

PROGRAM SIX***Living on the Edge***

Tuesday, November 26 at 9 P.M. and Thursday, November 28 (Thanksgiving Day) at 3 P.M. (ET; check local listings) on PBS.

Living on the Edge chronicles early and contemporary settlements in the American southwest, where sizzling sun and the lack of water challenge all that live there. The plants and wildlife live

in balance with the climate. Giant cacti, gila monsters, rattlesnakes, and scorpions are a few of the unique species that call the Sonora desert home.

PROGRAM SEVEN***The First and Last Frontier***

Wednesday, November 27 at 8 P.M. and Thursday, November 28 (Thanksgiving Day) at 4 P.M. (ET; check local listings) on PBS.

The First and Last Frontier highlights Alaska's spectacular wildlife and its current conflicts over oil and other exploitable resources which threaten its pristine wilderness.

PROGRAM EIGHT***Searching For Paradise***

Wednesday, November 27 at 9 P.M. and Thursday, November 28 (Thanksgiving Day) at 5 P.M. (ET; check local listings) on PBS.

Searching For Paradise is both an historic and contemporary look at the land along the Pacific Ocean that came to be known as California, after a mythic queen called "Caliphia."



Ron Shale

LAND OF THE EAGLE, a "Nature" special presentation, is a production of Thirteen/WNET in New York, in association with BBC Bristol. "Nature" is funded by underwriting grants from American Gas Association (A.G.A.); Siemens Corporation, a high-technology and electrical engineering company; and Canon, U.S.A., Inc. A companion book to LAND OF THE EAGLE, by Robert McCracken Peck, is available at bookstores from Summit Books. The series may be purchased by Time-Life Video and Television by calling 1-800-334-9933. BBC Executive Producer, Peter Crawford; Co-production series producer, Linda Romano; Executive Editor for "Nature," George Page; Executive Producer for "Nature," David Heeley.

Something New Out of Africa

by Peter J. Jarman

Richard Estes's book, *The Behavior Guide to African Mammals*, fuels an ancient and continuing European fascination with Africa and its wildlife, and it does so in a way that is novel and successful. Almost 2,000 years ago, Pliny the Elder, in his *Historia Naturalis*, reported a saying among the Greeks: "Africa always offers something new." Pliny himself brought together all that was then known about African mammals. Until well into the Renaissance, the classical writers were Europe's only source of knowledge about the large mammals of Africa. As Euro-

pean explorers, beginning in the fifteenth century, penetrated the African hinterland, they rediscovered the animals reported by Pliny and other classical writers. With nineteenth-century colonization of Africa, Europeans behaved like landed gentry, sequestering the right to hunt "game" and often punishing the indigenous people for hunting the same animals for food. In the late nineteenth and early twentieth centuries, sport hunters traversed the continent, shooting hundreds of animals and deliberately seeking out unexplored and unhunted country in the hope of shooting the best trophies. Africa's mammalian fauna, still so largely intact, diverse, and dramatic, supported the European and American growth of public museums and zoos. From these grew our knowledge about the kinds of mammals Africa contained and how those animals lived. Children remembered the elephant or lion or giraffe or zebra they had seen at the zoo. Visitors to natural history museums held those mammals poised forever in their dream of Africa.

Those who had the money, leisure, and means to travel turned to the real Africa to re-create those dreams. There were two kinds of visitors: biologists, drawn to the opportunities for research offered by the diversity and sheer abundance of African mammals, and tourists, who wished to experience the excitement or aesthetic delights of the wildlife. Tourism and science have now joined forces in the struggle to conserve wildlife and set aside parks. Through books, film, and television, the public of the Western world—potential tourists every one—now realize that there is more to seeing an animal than merely identifying it. They expect that the animal will do something interesting, describable, and explicable.

Estes's book has grown out of this back-

ground. He records in the preface that as a child he was inspired by Carl Akeley's dioramas of African "big game" at the American Museum of Natural History. He made it to Africa as a research biologist and later became a tour leader. Watching tourists in Ngorongoro Crater ticking off animals' names on their checklists but ignoring the animals' behavior, he resolved in 1967 to write a field guide to help tourists understand what the animals were doing.

However, Estes also wanted his book to serve as a reference work for behavioral scientists. Colleagues, he acknowledges, have questioned whether the same book can serve both readerships and both purposes. Estes robustly retorts that it can, and in many ways *The Behavior Guide to African Mammals* does succeed, although it requires a 600-page, two-pound, \$75 volume to do so. This is not a cheap, lightweight pocket guide.

Nor is the writing light. It is loaded with special terms (which take on added meanings if italicized) and written in a strict and repetitive format. Tourists will have to work to get full use of the book. They must read the introductory "Guide to the Guide" chapter simply to learn *how* to use the book. They must learn their way around it, and then they must learn to interpret descriptions of behavior.

Although the book does not contain photographs, Daniel Otte's numerous drawings help greatly. They illustrate a huge range of postures, actions, and activities, which have been chosen as being either characteristic of one species or typical of many. They come in a pleasing variety of styles (silhouette, sparse outline, ink wash, pencil shaded), and most are admirably clear. Many of the pencil sketches are full of action and atmosphere; for example, a springbok pronking (yes, that's the sort of technical term you have to look up in the glossary, where it says: "See stotting"), or a pair of bat-eared foxes "stressed by the presence of the ob-

THE BEHAVIOR GUIDE TO AFRICAN MAMMALS: INCLUDING HOOFED MAMMALS, CARNIVORES, PRIMATES, by Richard Despard Estes. University of California Press, \$75.00; 611 pp., illus.

pean explorers, beginning in the fifteenth century, penetrated the African hinterland, they rediscovered the animals reported by Pliny and other classical writers.

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An adult female baboon and a juvenile groom an adult male.

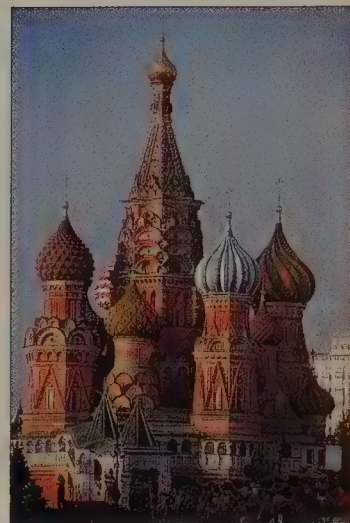
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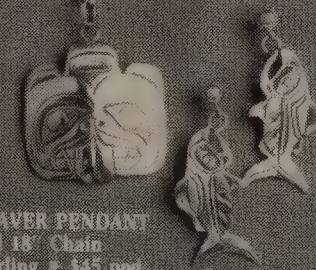
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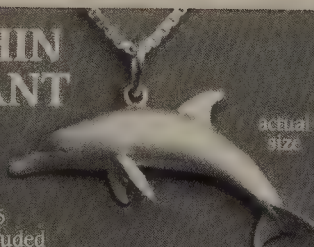
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server's vehicle." Sadly, the computer-drawn maps are less clear, and some species' distributions are hard to discern.

Estes has not tried to cover all species within the "hoofed mammals, carnivores, primates" of the title. Instead, he has selected those that are "most commonly seen in Africa's wildlife parks and reserves." In fact, the selection leans strongly toward the larger species of savanna and plains, which no doubt reflects where tourists currently go. Estes has evidently drawn upon his own years of experience of what one is likely to see. Forest and desert species receive less attention.

Among the carnivores, the behavior of many of the viverrids (the genets, civets, and mongooses) is described. Tourists do want to know about the mongooses they see by day and the genets and civets around their lodges and campsites at night. Most field identification guides have hitherto overlooked these active and endlessly delightful smaller mammals. The African wildcat and black-footed cat are also described, although neither is "commonly seen."

Of the scores of primate species in Africa, only two bush babies, four monkeys, and two apes receive detailed treatment. Perhaps few tourists are shown the many other monkeys, but scientists must be disappointed by the small selection. However, good general sections on the order of Primates and its families do much to compensate for that.

Hoofed mammals are well covered, and the text that deals with them is lively and readable. Estes himself has researched the behavior of several species of antelopes. "Sexually excited bulls," he writes, describing firsthand the wildebeest in rut, "call at twice the normal tempo and may become so worked up that they literally froth at the mouth." Massed herds in the rut make "a continuous humming and croaking like a chorus of giant frogs."

Estes examines each antelope species and compares habitat, food, size, body shape, coloring, degree of difference between male and female, and tendency to live alone or in groups. He demonstrates that in solitary species, males and females tend to look alike, and individuals tend to be smaller, to live in dense habitat, and to have rounded backs, concealing coloring, and short horns. Here Estes comes closest to showing his readers *why* particular forms of behavior suit each species' way of life.

Could the guide offer more help in where and when to look for behavior? I have spent memorable hours at water holes watching elephants playing, wrestling, even submerging, only to surface

underneath another, startled member of the herd. At dusk, when elephant cows, calves, and attendant bulls usually drink, I have even witnessed courtship. It would be an easy and useful tip to suggest water holes at dusk as the best place to watch elephant behavior.

From my own observations of impalas, I know that males most often roar, display with other males, and spar if they are in bachelor herds. Impalas in southern, but not eastern, Africa breed in a short, intense rut, when so much of the exciting behavior between males or between males and females can best be seen. Dawn and dusk are the times males will fight. What are the "best" times or places for seeing behavior? A table of the kinds of behavior to look for each month in different parts of Africa would have been a boon.

In one sense, scientists and some discerning tourists may find the book disappointing. The idea for the book arose more than twenty years ago, and the approach reflects that era to some degree. While the guide identifies and names an animal's behavior, there is no attempt to explain why such behavior exists. Take stotting, for example. This is the dramatic, stiff-legged, high-jumping gait of gazelles that have detected a predator such as a wild dog. Stotting is illustrated and mentioned several times as "expressing excitement," as "an alerting or warning signal," and as having "an important antipredator function." But stotting makes gazelles very conspicuous. So why do they do it? Research addressing just this question has shown that the gazelles that can stott fastest and longest are least likely to be killed. Far from being an altruistic expenditure of energy to warn others, stotting may be a way for a gazelle to show a predator that it is too fit to be worth chasing (*see* "Why Do Tommies Stott?" by Tim Caro, *Natural History*, September 1988).

E. O. Wilson writes in the foreword: "If you know an animal's behavior well, you know its essence." I would substitute "understand" for "know." This book certainly gives unparalleled access to knowledge of the behavior of Africa's large mammals; I question whether it as readily brings understanding within the reach of all readers. Nevertheless, it is a book that Pliny, the first great organizer and documenter of scientific facts, with his carefully acknowledged and referenced sources, would have loved. And the idea of a behavior guide is an excellent one—something new out of Africa, indeed.

Peter J. Jarman is head of the School of Natural Resources at the University of New England in New South Wales.

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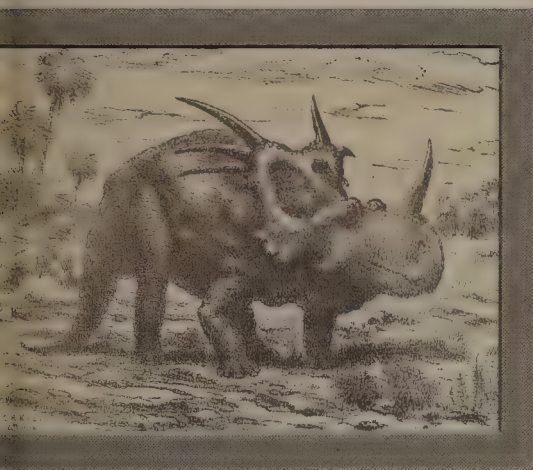
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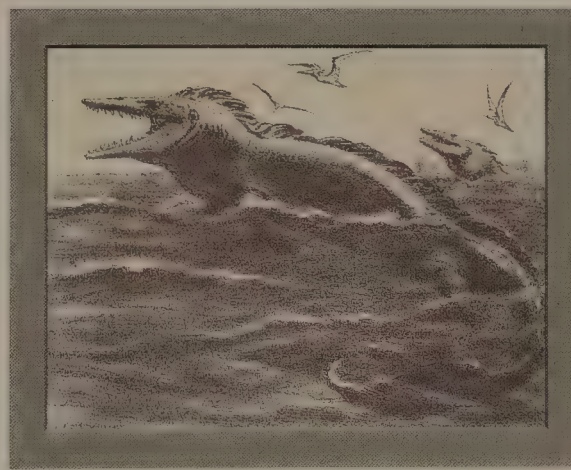
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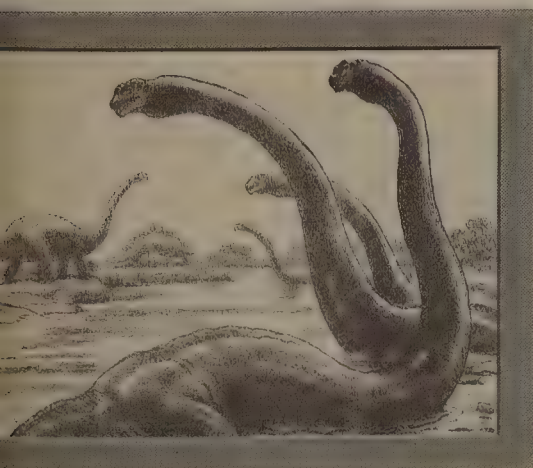
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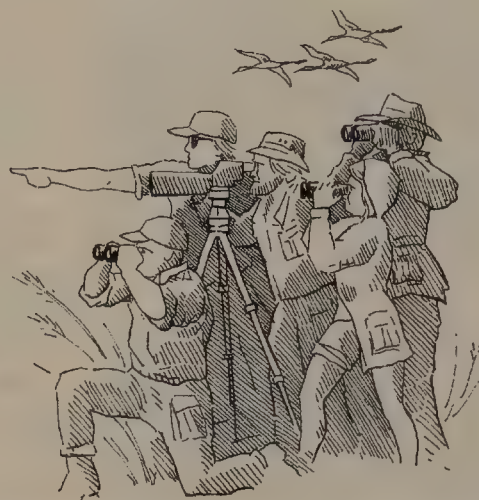
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Tenochtitlan, Teotihuacan, El Tajin, Cholula, Cacaxtla, Mitla, Monte Alban and the cities of Puebla and Cuernavaca.

Archeology of the Yucatan and Chiapas March 15-28, 1992

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CELESTIAL EVENTS

Hello from Planet Earth

by Gail S. Cleere

In the fourth century B.C., the Greek philosopher Metrodorus wrote, "To consider the Earth as the only world with life in all of space is as absurd as to believe that in an entire field sown with grain only one plant will grow." We celebrate this kind of cosmic thinking on November 16—the anniversary of the Arecibo radio message.

Seventeen years ago, the people of the planet Earth beamed up a three-minute radio message about themselves to M13, a particularly rich cluster of stars in the constellation Hercules, some 25,000 light-years away (down near the northwestern horizon after sunset in November). This was done on the theory that a concentration of some 300,000 stars would increase the chances that our signal might be detected by other intelligent life. Our species has been around for a few hundred thousand years—latecomers on a cosmic scale. We took our time getting fire sorted out; inventing the wheel, the printing press, the electric can opener; and finally finding the means by which we might converse with our cosmic neighbors. Perhaps there's someone else out there who's been in the business a bit longer.

The November 1974 experiment, using the huge Arecibo radiotelescope in Puerto Rico as a transmitter, was one of the earth's first purposeful messages to outer space. We sent information about the solar system we live in, about the population of the world at the time, and about the atomic elements we're made of. One wit suggested we might have sent the World Series scores instead.

But sending a quick message to outer space and spending time listening for such messages are viewed quite differently. In 1975, when NASA proposed a search for extraterrestrial intelligence, the program was laughed out of the halls of Congress. Senator William Proxmire, in one of his best lines, argued: "It's hard enough to find intelligent life right here in Washington!" Others agreed, claiming that hu-

mankind "represented the only intelligent species ever to exist in our galaxy."

But scientists argued that we had the technology already in place to do the searching, that it didn't cost huge sums of money, and that if we never tried, we would never succeed. Senator Proxmire eventually came around. Today, several programs around the world are tuned in to the great beyond. NASA is most heavily involved, with perhaps the best-known program, SETI (Search for Extra Terrestrial Intelligence). Harvard runs the META receiver (for Megachannel Extra Terrestrial Assay), which covers sixty-four times as many channels as its predecessor, Project Sentinel. In 1992, on the 500th anniversary of Columbus's landing in America, a dedicated group of scientists at NASA will begin a ten-year search for signs of extraterrestrial intelligence using a radio spectrum analyzer that will tune in to 10 million radio channels simultaneously.

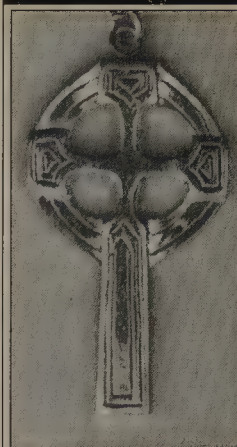
Even if we don't continue to send our messages, the earth remains quite a "noisy" little planet, electronically speaking, so there's always a chance of our being detected by others. The Air Force's Ballistic Missile Early Warning System and the Navy's Space Surveillance System are quite powerful—probably discernible tens of light-years away. As pioneer radio astronomer Frank Drake put it, "Peace on Earth is the biggest threat to others' hearing us." And as you know, we haven't yet learned to abide with one another peaceably as a species.

Definitely finding that intelligent life exists elsewhere in our universe would be perhaps the greatest event in all of human history. Humankind's view of itself would change irrevocably and forever. So, happy anniversary Arecibo message—fly on successfully.

THE PLANETS IN NOVEMBER

Mercury gradually becomes visible by midmonth, but just barely. Look for the

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planet low in the southwest just after sunset, not far from the star Antares in the constellation Scorpius, above which Mercury passes on the 11th.

Venus rises nearly four hours before the sun all month and is some forty degrees above the horizon by sunrise (forty-five degrees is halfway up to the zenith). Venus is a whopping -4.3 magnitude this month, just slightly dimmer than it was in October. There's no need to worry about spotting it, however. It will be the brightest object in the predawn skies, except for the moon when it's visible.

Mars is in conjunction with the sun this month, which means that the planet is directly opposite the sun. Forget about this "bloodstained, murderous god of War" (according to Homer) until early next year, when the warlord moves far enough away from the solar glare for us to see, initially in the morning sky.

Jupiter left us in July, slipping behind the sun as seen from the earth. This month, however, Jupiter rises high enough for even city dwellers to see it in predawn eastern skies. The giant planet is in Leo, along with Venus.

Saturn is about one-third the way up the southern sky after sundown. Because of the earth's rotation, Saturn can be seen drifting slowly to the west until mid-evening, when this golden, ringed beauty exits the heavenly stage for the evening.

Uranus and **Neptune** are just west of Saturn and above the handle of Sagittarius' "teapot," dipping under the western horizon about 8:00 P.M., EST. If you've a mind to hunt for these two, scan the skies—with an appropriate star map and a pair of binoculars—to the southwest just above the horizon.

Pluto is too close to the sun to be seen, even with the biggest telescopes.

The **Moon** is full on the 21st. It was called the beaver or snow moon in colonial America, the moon of falling leaves by the Sioux, and the moon when the bucks lose their horns by the Oto. New moon occurs

on the 6th, first quarter on the 14th, and last quarter on the 28th. On the evening of the 12th, look for Saturn a mere two degrees below the waxing crescent moon.

The Leonid meteor shower will peak on the evening of November 17-18, but this shower of "shooting stars" is one of the year's most unpredictable. In some years it has failed to show up at all. In 1933, the shower was described as "a child's sparkler held against the sky." In 1966, the Leonid shower burst over the central and western United States in the greatest meteoric display in recorded history, reaching an estimated rate of up to 150,000 meteors per hour for a period of forty minutes. The name, by the way, is derived from the point in the sky where the shower appears to emanate—the constellation Leo. This year's shower will be best in the hours after midnight and after moonset (about 3:00 A.M.).

The Leonids are the stuff of Comet Tempel-Tuttle, first seen by Ernest Tempel in France in December 1865 and independently discovered by Horace P. Tuttle in downtown Washington, D.C., in January 1866. The comet has a period of thirty-three years and was last seen in 1966. When Comet Tempel-Tuttle is in the earth's vicinity, the Leonid shower seems to get intense, literally, so mark the year 1999 on your calendars. Tuttle was a curious little man—a Navy paymaster at the time and an inveterate comet hunter whose astronomy logbooks are filled with the amusing scribbles of a determined sky watcher. Tuttle frequently signed his name in the shapes of small comets. In his logbook in 1859, Tuttle wrote: "Notice!! A comet is wanted immediately. Apply to H. P. Tuttle, P. S. He must have a Tail."

Gail S. Cleere writes on popular astronomy and is a founding member of the International Dark Sky Association, an organization dedicated to preserving the skies for astronomy.

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AT THE AMERICAN MUSEUM

CHIEFLY FEASTS

The potlatch ceremony of the Northwest Coast Indians is the focus of "Chiefly Feasts: The Enduring Kwakiutl Potlatch," an exhibition now at the American Museum of Natural History's Gallery 3 through Sunday, February 23. In conjunction with the exhibition, the Museum's Education Department is offering a number of programs.

In the Land of the War Canoes (1914) and *Box of Treasures* (1983) are among the films that will be presented on Saturday, November 9. The films are free and will be shown in the Linder Theater from 11:00 A.M. to 4:30 P.M.

Kwakiutl artist Kevin Cranmer will carve ceremonial masks and explain how they are used in Kwakiutl society. Cranmer will do his carving in the Northwest Coast Indian Hall from Friday, November 29, through Saturday, December 7, between 10:15 A.M. and 5:00 P.M.

The Wewanagila Dance Company will reenact the legend of the hero Born-to-Be-Head-of-the-World, as well as other stories of sea monsters, whales, eagles, sea otters, and Raven-of-the-Sea. Tickets are \$15 (\$13.50 for members). Performances will begin on Friday, November 29, and run through Friday, December 6, in the Kaufmann Theater. For information about times and ticket availability, call (212) 769-5305.

NATIVE AMERICAN MONTH

Ceremonial drumming and contemporary jazz, bone/antler carving and corn husk doll making, storytelling and dance will be among the presentations of Native American traditions during November and December. Topics of lectures will include wolves in Native American lore, ecology and the Iroquois tradition, contemporary Tlingit potlatch, Plains Indian clothing and quilts, and contemporary issues on the Navajo reservation. Short films will be shown each weekend as well. Programs are free and will take place in the Leonhardt People Center through December 15. For a complete schedule, call (212) 769-5182.

HOMES APART

A man journeys to find a lost sister in North Korea. In *Homes Apart: Korea*, filmmakers J. T. Takagi and Christine Choy portray a country in which 10 million families have been uprooted and scattered since the Korean War almost forty years ago. This documentary will be pre-

sented on Friday, November 1, at 7:00 P.M. in the Kaufmann Theater. Admission is free and seating is on a first-come, first-served basis. For information, call (212) 769-5315.

WILDERNESS AMERICA

Since the Wilderness Act was passed by Congress twenty-five years ago, nearly 91 million acres in the United States have come under its protection. A collection of approximately fifty photographs showing some of the rich biota of these preserves will be on display in the Akeley Corridor from Friday, November 29, through Sunday, January 19, 1992. This exhibition is sponsored by the Wilderness Society and the Timberland Company.

HUMAN BEGINNINGS

Recent fossil discoveries have yielded nearly complete skeletons of early man. Alan Walker, professor of cell biology and anatomy at the Johns Hopkins School of Medicine, and Meave Leakey, head of the Division of Paleontology of the National Museums of Kenya, will discuss their work at Kenya's Turkana Basin. This program will take place on Thursday, November 7, at 7:30 P.M. in the Main Auditorium. Tickets are \$20 (\$12 for members). For information, call (212) 769-5606.

TELESCOPE TECHNOLOGY

Hal McAllister, of Georgia State University, will talk about telescopes that will allow us to see 100 times more clearly



Superior National Forest, Minnesota

American Museum of Natural History

EXPLORING THE MAYA COAST

Mexico, Belize and Honduras

February 5-15, 1992

than before and will pave the way for observatories on the moon. "Revolutionizing Astronomy from the Mountains to the Deserts," part of the Frontiers in Astronomy and Astrophysics Lecture Series, will take place in the Planetarium Sky Theater on Monday, November 18, at 7:30 P.M. Tickets are \$6 (\$5 for members).

Gerard Rancourt Tsonakwa, an Abenaki Indian, will relate ancient legends about the night sky on Saturday, November 16, at 10:30 and 11:45 A.M. in the Sky Theater. Tickets are \$8 for adults (\$6 for members) and \$6 for children (\$4 for members). Call (212) 769-5900 for ticket availability and information on other Planetarium programs.

SPOTLIGHT TOURS

Museum visitors may now take free special-interest tours on subjects ranging from meteorites to dinosaurs. Highlight tours of the Museum's collections still leave daily from the first-floor information desk, beginning at 10:15 A.M. For details, call (212) 769-5566.

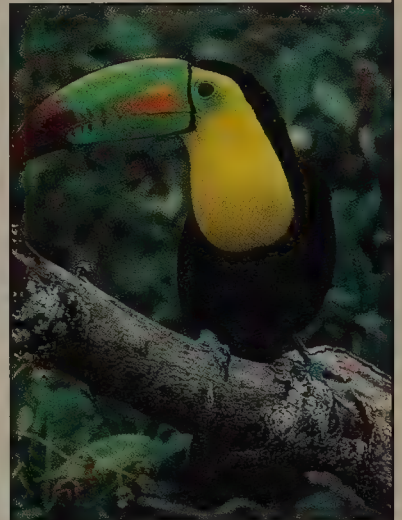
These events take place at the American Museum of Natural History, located on Central Park West at 79th Street in New York City. The Kaufmann and Linder theaters and the Leonhardt People Center are located in the Charles A. Dana Education Wing. The Museum has a pay-what-you-wish admission policy. For more information about the Museum, call (212) 769-5100.

Craig and Nadine Blacklock



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The Universal Penitential Fish

A staple in northern Europe since medieval times, cooked cod found a second home in the Catholic Mediterranean

by Raymond Sokolov

We hear a lot about the information revolution, and I suppose it affects even people who still write with pens or typewriters and never run a spreadsheet or dial up a database. I'm writing this on a computer, and the convenience that word processing offers for revision—no more crunched pieces of paper or illegible palimpsests covered with corrections and emendations—has improved the quality of my life even if it hasn't noticeably improved the end product. Even better is the computer's ability to search almost instantaneously across a very large collection of articles and records for a single word or phrase.

For example, if I want to see everything I've written for this magazine since 1987 on pomegranates, the computer will whiz unerringly to each of those locations in thousands of words of text. This may seem like a trivial capability, but think what it would mean for any kind of research if a major library put its entire collection "on line." Not long ago this would have been unthinkable because of machine limitations in memory and speed of retrieval, but those limitations have all but evaporated. And the necessity to hire human beings to keystroke every page in the Library of Congress has also been eliminated, to a major degree, by advances in electronic scanners, machines that absorb normal text into electronic memories so that a computer can read them.

For anyone interested in food and cooking, this development is of high interest. As things stand now, if I want to inform myself about the way human beings all over the world across recorded time have dealt with a particular ingredient, I have to make a calculated guess about which books to look at, and I have to be careful about the amount of time I can spend on

the project. I am also limited by my ability to get my hands on the books I want in a way consistent with writing on a fresh subject every month. Even if I were able to spend large amounts of time reading at a major cookbook collection like that at the New York Public Library, I would still never be able to do a full-press search.

But when that library goes on line, I'll be able to tap into the entire corpus of written discussion—in virtually any book there is—from my desk at home, dialing the library's global database and searching for lemon or caraway or *dulce de leche*. As things stand now, I depend almost exclusively on an old-fashioned private library of food books shelved in my home. When the monthly obligation to this magazine becomes ineluctable, I get

on my ladder, pull down a few dozen books that strike me as promising, and flip through them, trolling for gold.

This month, I've actually been trolling for fish. As we approach the holiday season, fish becomes holiday food for many Catholics. In the supermarket in New Paltz, New York, that I frequent, the meat counter fills up with a special pelagic menagerie just before Christmas Eve—eels, octopus—to round out the traditional meal of seven fish or thirteen, some prime number seems essential. (I intend to focus on this tradition exclusively in the future, perhaps next year, and look forward to any information from readers, since standard sources ignore it, as far as I can tell.)

In Rome and Naples, the tradition of the Christmas vigil dictates big, fat, unprepossessing eels, *capitoni*, caught in Ortebello and stewed with herbs. And in many places, *baccalà* (salt cod) is obligatory. There seems to be no doubt that these fish meals preserve the idea of penitential food best known from Friday and Lenten "meager" meals, at which the pious, until quite recently, abstained from meat and substituted fish. In Michigan and Ohio during the Depression, Catholics were permitted to count muskrat as fish for Lent and on Fridays, an indulgence, so to speak, that has left behind a vestigial regional taste for that animal around Toledo and Detroit's downriver communities. (I have also seen muskrat, euphemized as marsh rabbits, for sale in historically Catholic Maryland.)

Cod is the most universal of the penitential fishes. In the same family as haddock (*Gadidae*), *Gadus morhua* L. is among the most influential of the food fishes. From medieval times, at least, its abundance in north European salt waters made cod a crucial source of nutrition locally



Dried cod

Tyler Gearhart; Envision

ANCIENT CAPITALS OF THE ORIENT

China, South Korea and Japan

June 2-17, 1992



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- Yosu, along South Korea's spectacular southern coast, where General Yi defeated the Japanese in the 16th century with his famous "turtle ships." Also visit the Chinnamgwon Pavilion and lovely Odong-do Island.
- Kyongju, South Korea, one of the world's great historic sites, with its wonderful National Museum and excavated temples, palaces, shrines and tombs built between 57 B.C. and 935 A.D.
- Matsue, Japan's enchanting city of willow-lined canals and historic houses. Explore Daisen Oki National Park and the Izumo Taisha shrine, Japan's oldest Shinto shrine.
- Hagi, a picturesque Japanese town famous for its fine porcelains and beautifully-preserved historic Samurai district.
- Japan's colorful Itsukushima Shrine, which appears to float on the water during high tide, on the beautiful island of Miyajima.
- The world-famous Inland Sea of Japan, with picturesque fishing villages and hundreds of pine-clad islets.
- Two days in Kyoto, an architectural treasure trove with hundreds of temples and shrines symbolizing the beauty and grace of ancient Japan.
- Ise Shima National Park, where the two most venerated Shinto shrines are located, and Mikimoto Kikichi's pearl culture farm on Pearl Island.



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ARCHEOLOGY OF THE YUCATAN AND CHIAPAS, MEXICO

(Equinox at Chichen Itza)

March 15-28, 1992

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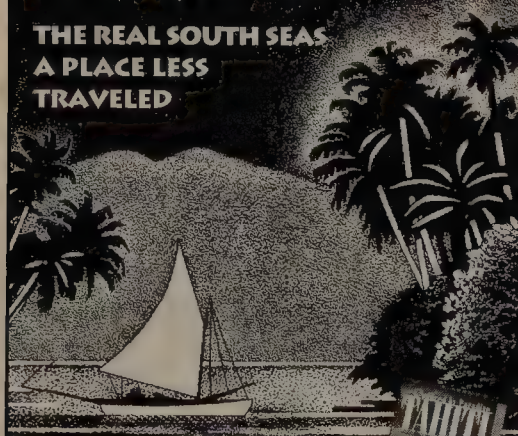
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and an important commodity in an ancient commerce with the south. After Columbus, the even greater abundance of cod in the western North Atlantic, especially off Newfoundland, may have been a major impetus to settlement on what became the eastern coasts of Canada and the United States.

Cod can get quite large, up to almost ninety pounds; we call small ones scrod. In any size, it is a fine fish eaten fresh and cooked in all the usual ways. In the days before refrigeration, Norwegians and Britons, and no doubt other cod-eating peoples, kept cod fresh for market in special boxes. There is a debate about the benefit of this.

Some fishermen and other fanatics say that cod is better when it isn't absolutely fresh. Alan Davidson, the leading ichthyophage of all time, describes in *North Atlantic Seafood* (Viking, 1980) how he watched a Norwegian scientist as he took a live eight-pound cod from a tank in a Bergen market, had it cleaned and bled, let it rest for an hour, and then cut it into ¾-inch steaks. He let the steaks stand under cold running water for a few more hours, then set them in boiling salt water (3 percent saline, like the sea). Once the water returned to the boil, he removed the pot from the heat and left the steaks to cook for five or six minutes. They emerged "snow-white, tender and delicious." The professor served them with "floury" boiled potatoes and melted butter, nothing else, except a bit of lettuce afterward, so as not to obscure the fish's subtle flavor.

He told Davidson he would have preferred cooking the cod in whey if he'd had any, since then it would have been even whiter and firmer.

Aficionados of fresh cod also batten on the roe, the cheeks, and the tongues (really the throat muscles), which Davidson says are baked in white sauce in Bergen; in Iceland, where you should ask for them as *gellur*, they are poached, either fresh or salted.

Fresh cod, for reasons of technological history, is a north European dish. Davidson, in his minidatabase of recipes, concentrates on delicacies of Scandinavia (Danish fruit soup with cod) and Britain. France, the southernmost source, contributes *cabillaud aux fines herbes*.

France is actually the transition point between fresh cod and preserved cod. The language shows it. *Cabillaud* is fresh cod, *morue* is salt cod, and *merluce* is dried cod, or stockfish. In the south of France, the salt and dried versions predominate and form a totally assimilated northern presence in local cuisines. The innumerable recipes testify to the longevity of the preserved cod trade with the north. Spaniards, Italians, and Portuguese all took preserved (especially salt) cod to heart with perhaps even greater enthusiasm than the French. Even though they had fresh fish from their own shores, religious obligations compelled them to eat so much fish in the course of the year that a healthy supplement of long-keeping cod from the teeming schools of the north was necessary. And the colonizing Mediterra-

Old-fashioned Salt Cod Cakes

(Slightly adapted from *Jasper White's Cooking from New England*, Harper and Row, 1989)

- 1 pound boneless salt cod, soaked overnight
- 2 pounds russet or Maine potatoes, peeled and cut in half
- ½ small onion, finely chopped (¼ cup)
- 4 tablespoons unsalted butter
- 1 teaspoon Coleman's dry mustard
- Worcestershire sauce
- 1 egg
- 3 egg yolks
- Black pepper
- Flour for dusting
- ½ pound slab bacon cut in strips, ¼- to ⅜-inch thick
- Parsley
- Lemon wedges

1. Remove the cod from soaking liquid, place in a flat pot, and cover with cold water. Bring to a simmer. Simmer for five minutes and remove. Drain well. Break cod into flakes and keep warm.
2. Boil the potatoes in salted water until

- done (about 30 minutes). Drain thoroughly in a colander. It is important for the potatoes to be as dry as possible. Cook the onion in the butter until limp.
3. Purée or mash the potatoes while still warm. Add the melted butter and onion, flaked fish, dry mustard, and a few dashes of Worcestershire sauce. Add the egg and egg yolks. Mix thoroughly with a fork. Season with pepper. Form into small cakes and chill in the refrigerator. This may all be done as much as 4 hours in advance.
4. When ready to serve, dust the fish cakes with flour. Pan fry the bacon until browned but not too crisp; remove from pan and keep warm. In the same pan, fry the fish cakes in the bacon fat, about 2 minutes on each side. Serve with the small slices of bacon, parsley, and lemon wedges.

Yield: 6 to 8 servings

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FEBRUARY 2-13, 1992

near countries spread this easily transportable protein source to their outposts in the Caribbean, South America, Asia, and Africa.

Today, the Spanish Caribbean is a rich source of recipes for *bacalao*. *Bacalhau* is a staple of Brazilian cooking and also turns up in Macao. In this country, salt cod did not last as a major food, probably because new immigrants from England weren't used to it and could get by without it. Codfish balls, however, survive as a regional oddity in New England. In our Midwest, die-hard sons and daughters of Scandinavia have made a special form of dried cod the emblem of their ethnicity. *Lutefisk* is cod processed with lye. It has a strong odor and a memorable flavor, shall we say. Plain air-dried cod, or stockfish (Italian *estocafisso*), has fared well outside its home base in Scandinavia.

Stockfish, hard as wood, is the eponymous ingredient in the most typical dish of Nice, *estocaficada*. In his classic *Cuisine of Nice* (Penguin, 1991), Jacques Medecin recommends that stockfish be soaked for eight days before it gets cooked in the stew it gives its name to. By legend, an impatient old fisherman in the area used to pulverize it with a hammer on a rock. After cooking it with garlic, oil, and chilies, he would then smear it on bread. Strong stuff.

Most of the dried cod cooked around the world is salt cod. You can often find it in American supermarkets, but many people avoid cooking it, because they think it will be aggressively salty or they don't want to bother with the preliminary soaking that's necessary to purge most of the salt and rehydrate the fish and make it wonderful.

The intricate method of soaking cod, which Madame Saint-Ange prescribed in her bible of French bourgeois cuisine, sounds like a nightmare of rinsings and careful treatment. I've found that just putting the stuff in a couple of changes of cold water to soak for twelve hours or so will do the job. And then you have a sort of passport to a database of recipes from all over, from the rich, oily purée called *brandade* (from an old French verb meaning to agitate, because of the hand mixing necessary before food processors) to the delicate fritters you get on the beach in Puerto Rico. Unless you absolutely won't fry at home, these *bacalaitos* are now a snap to make. There is a commercial mix on the market. Just add water and drop in hot fat. No soaking at all.

Raymond Sokolov is a writer whose special interests are the history and preparation of food.



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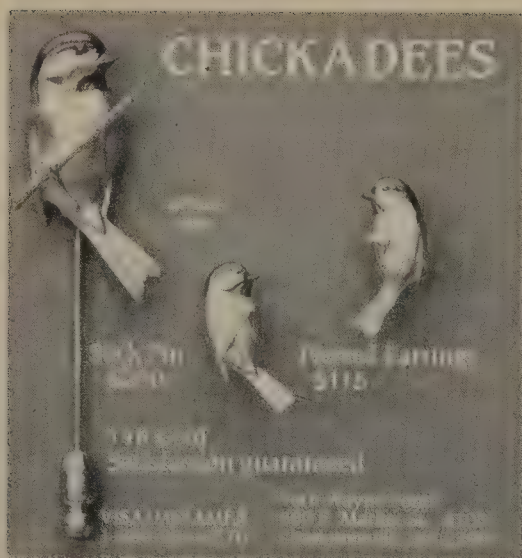
Classical mythology tells of a “king of the serpents” known as the basilisk (from the Greek *basileus*, “king”), endowed with a crownlike crest on its head. This magical creature was described by the Roman naturalist Pliny: “He does not creep on the ground, like other serpents, but advances lofty and upright. He kills the shrubs, not only by contact, but by breathing on them, and splits the rocks, such power of evil is there in him.”

When several species of crested lizards that can run bipedally were discovered in South America in the eighteenth century, zoologists named the genus *Basiliscus*, after the fabulous royal reptile. Travelers, amazed by the basilisk’s ability to run on water, nicknamed it the Jesus Christ lizard.

Omnivores that feed on small animals and plants, basilisks live in the tropical rain forests of southern Mexico, Central America, and northern South America. These two-foot-long lizards, with their specially adapted feet, are able to run across streams and ponds at such high speeds that they barely break the surface film—an act no predator (except birds) can follow.

Basilisks have special membranes that are normally curled around their toes when they travel on land. However, these flaps of skin unfurl on water and act like snowshoes to retard sinking. Since the lizards move rapidly, producing a close-up like this one is difficult, if not impossible, in the wild, so naturalist-photographer Stephen Dalton set up an artificial pond about twelve feet long in his studio in Sussex, England. When it sprinted across the water’s surface, the basilisk broke a beam of light, tripped a photoelectric shutter, and took its own picture.—*R. M.*

Photograph by
Stephen Dalton NHPA



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AUTHORS

Born in Edinburgh, Scotland, in 1926, **Ian Rowley** (page 44) moved to Australia in 1949 and has spent much of his time since then studying the fauna of his adopted country. After earning a degree in agriculture from Melbourne University, he joined the Wildlife Survey Section of the Commonwealth Scientific and Industrial Research Organization and recently retired as a senior principal research scientist of that organization. In addition to his long-term work with galahs and Major Mitchell cockatoos, Rowley conducted field research for seventeen years on Australian fairy wrens

and plans to publish a book about this group of birds. His work with generations of color-banded birds stems from his interest in "how animals interact with each other as individuals." Birds, he adds, "happen to be easy to see." More information on the avifauna of Australia can be found in Rowley's books *Bird Life* (Sydney: Collins, 1975) and *Behavioural Ecology of Galahs* (Sydney: Surrey, Beatty, 1991). The classic compendium of parrots, including cockatoos, is Joseph M. Forshaw's *Parrots of the World*, 3d rev. ed. (London: Blandford Press, 1989).



Freezing the movements of an animal that can run across the surface of water presents no difficulties for **Stephen Dalton** (page 92), who photographed this month's "Natural Moment." A native of England, Dalton works in rural Sussex, where he lives with his wife and four children. He uses an old barn for studio setups and also goes out into the surrounding countryside to create portraits of the living communities found in the lakes and woods. Dalton's work has been honored with the Hood Medal of the Royal Photographic Society, the Nikon

Award, the Farrand Award, and the Sir Peter Kent Conservation Book Prize for his volume *At Water's Edge* (1989). The latest of his many books of wildlife photography is *Vanishing Paradise: The Tropical Rain Forest* (New York: Century Hutchinson, 1990). For the shot of the running basilisk, he used a Hasselblad with a 150mm lens, set at a shutter speed of 1/500 of a second. When the lizard broke a photoelectric beam, it triggered not only the shutter but also electronic strobes, which illuminated it for 1/10,000 of a second.



Fleshing out *Gigantopithecus*, the largest primate that ever roamed the earth, is an obsession with paleoanthropologist **Russell L. Ciochon** (page 54), who will lead a second expedition to Vietnam's Lang Trang caves this February in hopes of finding new fossils of the creature. Ciochon (shown here, at right, with Chinese paleoanthropologist Xie Guangmao) and archeologist John Olsen have also been invited to pursue the search with Chinese scientists at excavations in Sichuan Province. An associate professor of anthropology at the University of Iowa, Ciochon has previously reported for *Natural History* on early fossil primates in Burma (October 1985) and on the ruins of Angkor, Cambodia's ancient capital (January 1990). He is currently collaborating with John Fleagle on *The Human Evolution Sourcebook*, to be published by Prentice Hall in 1992. For further reading about the "ape that was," he recommends "Geomorphology to Paleoecology: *Gigantopithecus* Reappraised," by Tim D. White (*Journal of Human Evolution*, vol. 4, May 1975, pp. 231-33), and *Other Origins: The Search for the Giant Ape in Human Prehistory*, by Russell Ciochon, John Olsen, and Jamie James (New York: Bantam Books, 1990; London: Gollancz, 1991). Ciochon will lecture on *Gigantopithecus* at the American Museum on January 30, 1992.

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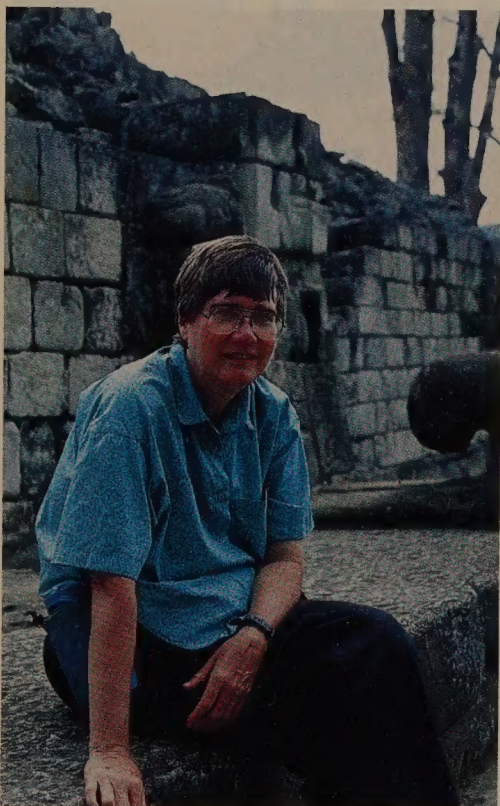
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Carolyn M. King (page 34) was brought up on a farm in Kent, England, and first became interested in weasels (which she fondly calls "hair-trigger mousetraps with teeth") in 1967 as a graduate student at Oxford. The university owned a wooded estate, and King decided its weasels held "instant appeal" as the subject of her thesis. It took several years of determination and persistence to finally penetrate the weasel's world, winning her a doctorate in animal ecology in 1971. Shortly thereafter, she moved to New Zealand, where she continued her research and in 1983 was appointed scientific editor at the Royal Society of New Zealand. In addition to her forty scientific papers on weasels and



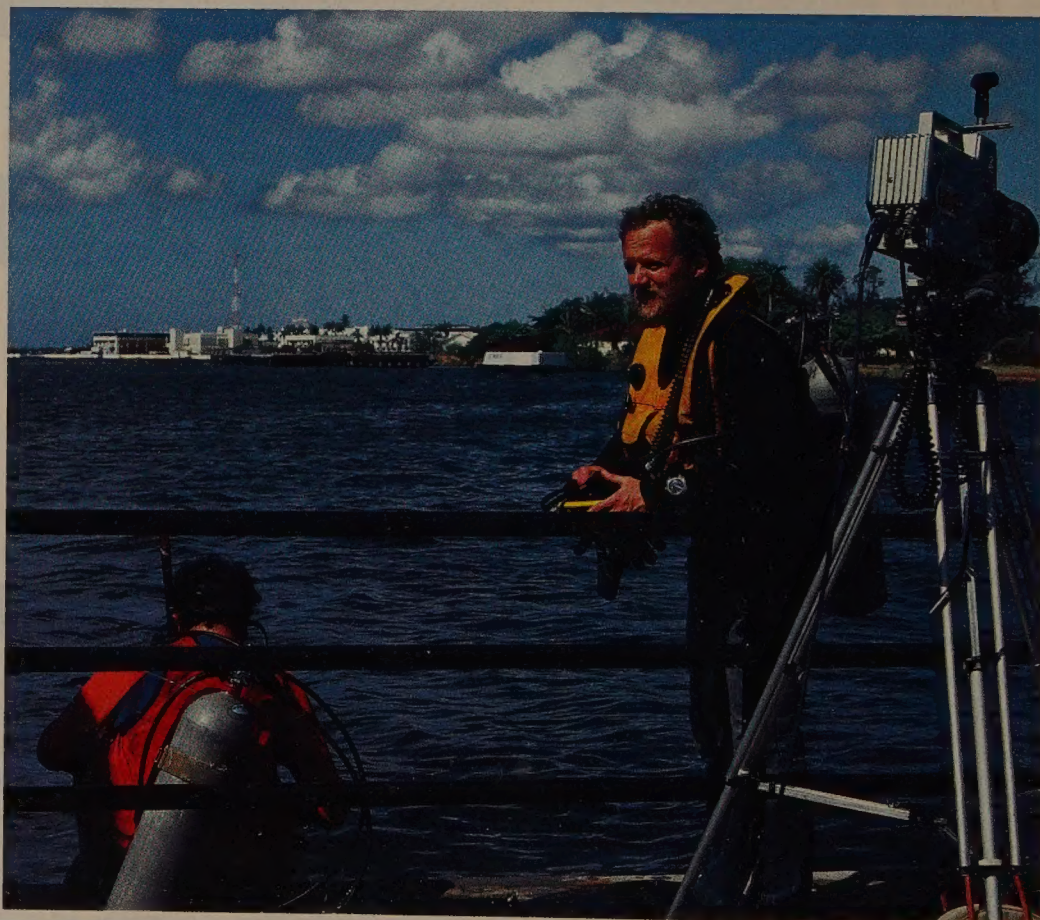
stoats, she is the author of *Immigrant Killers* (Auckland: Oxford University Press, 1984) and *The Natural History of Weasels and Stoats* (London: Christopher Helm, 1989). Recently, she edited the *Handbook of New Zealand Mammals* (Auckland: Oxford University Press, 1990). King lives in Havelock North, Hawke's Bay, with her husband and fourteen-year-old son; her main interest outside natural history is contemporary theology. For further reading on weasels, she recommends *Sleek and Savage*, by Delphine Haley (Seattle: Pacific Search Press, 1975), and "The Graceful and Rapacious Weasel," by E. Raymond Hall (*Natural History*, November 1974).



When first asked to look over the sunken battleship *Arizona*, **Daniel J. Lenihan** (page 64) was taken with the challenge of mapping something in murky water that was three times the size of the Statue of Liberty. Based in Santa Fe, Lenihan is chief of the National Park Service's team of underwater archeologists, known as the Submerged Cultural Resources Unit. As part of continued research in Pearl Harbor, he hopes to locate the Japanese midget submarine that was sunk before the air raid began. Recently, he also completed a survey of various ships that were sunk at Bikini during the atom bomb tests of 1946, including the *Nagato*, the flagship of the Japanese

Navy during the attack on Pearl Harbor. For additional reading, he suggests the following publications (all available from the USS *Arizona* Memorial Museum Association, 1 Arizona Memorial Place, Honolulu, Hawaii 96818): *At Dawn We Slept*, by Gordon W. Prange (New York: Penguin Books, 1982), *East Wind Rain*, by Stan B. Cohen (Missoula: Pictorial Histories Publishing Company, 1981), *Hawaii Under the Rising Sun*, by John J. Stephen (Honolulu: University of Hawaii Press, 1984), and *Submerged Cultural Resources Study: USS Arizona Memorial and Pearl Harbor National Landmark*, edited by Daniel J. Lenihan (Santa Fe: U. S. Department of the Interior, 1989).

Now recognized as a major topic of Maya inscriptions, conquest warfare is one of the many facets of that civilization studied by **Linda Schele** (page 6). The pivotal conflict between Tikal and Uaxactún was first brought to her attention by archeologist Peter Mathews. Schele is John D. Murchison Professor of Art at the University of Texas, Austin. Among her publications are *The Blood of Kings: Dynasty and Ritual in Maya Art*, coauthored with Mary Ellen Miller (Fort Worth: Kimbell Art Museum, and New York: William Morrow and Co., 1986), and *A Forest of Kings: The Untold Story of the Ancient Maya*, coauthored with David Freidel (New York: William Morrow and Co., 1990). For additional reading she also recommends *The Maya*, by Michael D. Coe (London: Thames and Hudson, 1987).



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